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1. INTRODUCTION

Natural resources constitute an important component of the life support system. The Himalayan mountain region is a set of complex ecosystems that has been under sustained and intense exploitation by the humans, since the turn of this century. This threat from the humans from within as well as from outside is constantly on the rise. Maintaining the ecological integrity of these mountain ranges is not only important for the well being of the people in these uplands, but the destiny of the Indian sub-continent itself is directly linked to the health of the Himalayas. Large-scale perturbations in the Himalayan region could influence the water retention/release capabilities of these upland ecosystems in such a manner that they could determine water discharge into the plains of India, leading to flooding and erosion during the monsoon and causing drought at other times because of drastically reduced discharge of water.

With a long stretch of over 2500 km extending from south east to north west, the region has complex ecosystem types, under varied climate, topography and soil. Diversity in socio-economic and socio-cultural features of the mountain people add to the complexity of the environment and to the task of sustainable development of the mountain ecosystems.

Land and water form the backbone of the resource base on which agriculture, forestry and animal husbandry linkages depend, in these upland regions (Ramakrishnan, 1988). Ranging from shifting agriculture (jhum) in the north-east to intense terrace farming in the north-west Himalayas, this interlinked system is critical for the hill people. The ultimate expression of the traditional complex farming systems found in the region is through, perhaps, the 'home gardens', a concept of farming based on imitating the forest. A thorough knowledge about the traditional farming systems could form the base on which more modern agroforestry systems could be based. In this effort, water harvesting and management is important.

The rural setting in the hills is varied, based on ecologic, socio-economic and cultural factors. Traditionally, the system is strongly rooted upon the concept of recycling of resources within. With rapid break-down of the linkages within the rural ecosystem, because of population pressure and the consequent over-exploitation of resources, development based on ecologic considerations is the answer. Sustainable development should link up with energy related issues including non-conventional energy production through wind, water and biomass. Rural industries for processing primary produce from the rural areas and removal of drudgery of women are other aspects that are part of an integrated planning strategy.

Exploitation of the large resource base of the hills by industry through mining, large-scale timber extraction or hydro-electric power generation from the hill streams and rivers have both positive and negative side effects. Environmental costs, therefore, need to be integrated with traditionally practised cost-benefit analysis. Identification of strategies for ameliorating environmental damage and looking at alternate pathways for development are important aspects of environmental cost-benefit analysis.

The extreme ecological diversity contributes to a rich biological diversity. Ranging from dry deciduous forests of the north-west to extremely fragile rainforests of the north-east along the longitudinal gradient, reaching upto alpine meadows through temperate conifer or broad leaved forests to sub-tropical forests along the altitudinal gradient, the ecosystem diversity is remarkable indeed. This being presently threatened for various reasons, conservation of this diversity is critical for the very survival of the hill people and those in the plains. These fragile ecosystems which are repositories of rich germplasm of traditionally used plants also contain many lesser-known plants of value, plants for food, drugs and chemicals and for their sheer aesthetic value. Conservation strategy need to be based on an integration of ecological and social considerations.

In order to achieve the above objectives, appropriate institutional mechanisms need to be created through a link-up between those established through a bottom-up approach created with peoples' participation and those already available through a top-down approach of the Governmental agencies. Linkages between natural and social scientists, Governmental and Non-governmental agencies, with people as the focal point is crucial not only to create awareness through education, but also to ensure peoples' involvement at all stages of development, right through the phases of conceptualization, planning, implementation and monitoring.

The following account is an attempt to capture the extreme complexity of the systems that are involved in the Himalayan region, making the task of sustainable development difficult and highly location-specific. After a general discussion of the problems and issues specific to mountain ecosystems and those in the context of the Himalayan setting, the complex solutions relevant to sustainable development of mountain ecosystems are elaborated through two case studies - one from the north-eastern region and another from the north-western Himalayas. The following account is an attempt to look at sustainable development from a holistic perspective, capturing all the different linkages, interactions and feedbacks, as brought out in the concluding part.

2. PROBLEMS RELEVANT TO MOUNTAIN DEVELOPMENT

2.1. Development Concerns for Mountain Areas

Mountain areas were ignored in the past in respect of developing a scientific understanding of the dynamics of natural resources, and organization and evolution of human systems. Several reasons account for the relative neglect of mountain ecosystems. The age old traditions which associated mountains with dangers, catastrophes/ supernatural events and poor connectivity impeded the process of building on the scientific knowledge. On account of preexisting low level of economic growth coupled with lack of adequate infrastructural facilities needed for expanding the market economy, mountain areas were considered peripheral to core resource use areas in lowlands. This apparent lack of attention left mountain ecosystems with a paucity of data, and sketchy and scattered literature. However, a realization about the potentialities of mountain regions did exist. Hart (1968) while highlighting the importance of British highlands visualized 'as more and more of low land disappears beneath bricks and mortar, steel and concrete, tarmac and asphalt, so the upland areas, underpopulated and underdeveloped, must gain greater importance both for the physical and for the spiritual nourishment of the people'.

Patterns and processes affecting natural as well human systems in the mountains influence not only the mountain people but also those living in the adjacent low land areas. Development prospects of 90 % of world population living in 75 % of the earth's low land surface is intimately bound to what happens or does not happen in highlands (areas more than 1000 m in altitude) which occupy only 25 % of the earth's surface and where only 10 % of the world population lives (Eckholm, 1975).

New technologies and economic forces did penetrate the mountain ranges in developing countries *viz.,* the Himalaya, the Andes and the East African Mountains, but to a much less extent than in the low lands. While socio-economic and ecological conditions have already been radically transformed in low lands, remote and difficult mountain societies have not changed much from their age old traditional life styles. Pristine natural ecosystems do exist in the high lands. Adverse impacts of economic growth on environmental/ natural resources are thus much less extensive in mountains than in the low lands. Fragility of mountain landscape and low level of socio-economic development led to proliferation of extreme stands on what should be the direction for changes in the future: environmentalists advocating for preservation/conservation of undisturbed natural ecosystems together with regeneration of degraded ecosystems and economists advocating for utilizing mountain resources for socio-economic development. With increase in exposure towards the realities of life of marginalised highlanders and with changing attitudes of mountain people towards new technologies, economic forces and other changes

taking place in the lowlands, the need of reconciling extreme economic and environmental stands assumed more and more prominence. Emergence of sustainable development initiatives as global concerns in the recent couple of decades, compelled extremists to concentrate on evolving environmentally sound socio-economic development packages and put them to practice. Conspicuous qualitative as well quantitative differences between mountains and lowlands in respect of landscape, natural resources, human resource, level of technology stimulated comprehensive thinking in what way development strategies for the mountains be different from other areas (Rhoades, 1988; Ives & Massereli, 1989; Jodha, 1990; Anonymous, 1992c & d).

2.2. Mountain Specificities

Slope and altitude are the key features distinguishing mountains from other areas (Forman, 1988; Allan, 1986). Mountains occupy a three dimensional space in contrast to two dimensional spatiality of lowlands. Slope and altitude considerably vary and this variability gets manifested as landscape heterogeneity/diversity within a given mountain system. Unique geographical location of the Himalaya, along with geological processes influencing the region, further magnify/diversify the effects of slopes and altitudes. West to east gradients of increasing average annual rainfall and temperature as a result of monsoonic climate create diverse environmental conditions within an altitudinal zone or slope zone. Variability in slope becomes apparent as an array of hills and valleys or dissection of the mountain system. Dissected landscape restricts mobility, thereby making mountain areas more inaccessible than the lowlands. Physical stresses impeding mobility enforce self-reliance to the maximum possible extent and restrict exchanges for securing livelihood.

Earth surface processes like erosion and stream flows often assume exceedingly high levels particularly during the monsoons in the Himalaya. This gets manifested as slope failure phenomenon. Since Himalaya is a young formation where upliftment process is still continuing, slope failures become more frequent, particularly when earth surface is altered through processes like deforestation and slope cutting. Equilibrium or near equilibrium ecosystems are evolved over fairly long periods. Ecosystem patterns and processes and maintaining equilibria are complex and highly sensitive to human interferences. Human capacity, in terms of available technologies and/or capacity to implement the available technologies, often fails to reverse the environmental degradation processes triggered as a result of natural catastrophic events like cloud burst, rainstorms, lightening, earthquakes or human interferences imposing severe and/or frequent disturbances, like clear felling, intensive cropping, overgrazing, burning, mining, *etc.* Susceptibility of mountain environments to irreversible degradational processes is commonly referred to as fragility.

Mountain features, specificities and their implications for development have been interpreted in different ways, over the last two decades in order to stress the importance and urgency for reorienting conventional development planning (Allan *et al.,* 1988; Ives & Massereli, 1989; Jodha, 1990; Sanwal, 1989; Ramakrishnan, 1992a; Scott & Walter, 1993; Stadelbauer, 1991). Jodha (1990) considered six important mountain specificities - inaccessibility, fragility, marginality and diversity or heterogeneity as first order specificities, and natural suitability or 'niche' and human adaptation mechanisms as the second order specificities. Inaccessibility and fragility impede the development processes which could bring mountain regions close to the mainstream. Marginality seems to be an apparent expression of effects of inaccessibility and fragility.

Table 1. Positive and negative values of Himalayan Environment.

Positive values	Negative values
Atmospheric purity	Unpredictable catastrophic events (cloud bursts, rain storms, earthquakes, land slides)
Pleasant summer seasons	
Aesthetic beauty, solace/peaceful environment	Harsh winter and rainy seasons
	Poor connectivity (transport and communication)
Abundance of natural resources with knownutility values (water, hydropower, natural vegetation, cultivated crops, wild edibles, variety of wild and cultivated crops)	Low level of advanced technology infrastructural facilities and welfare services operated by the Government
	Poorly developed cash driven market
	Low level of local financial capacity

A different way of looking at the mountains would be to focus on values tagged to mountain features or specificities by common man. Positive and negative values, as elsewhere, prevail for the mountain regions too (Table 1). Positive values *viz.,* atmospheric purity, pleasant summer season, aesthetic beauty and solace/ peaceful environment are concerned with abstract happiness. These values in the present circumstances favor transient stays under desperation or exhaustion or for

curiosity making mountains more as refuge or resort rather than a preferred choice for permanent settlements. Abundance of natural resources and their diversity offer positive values from the point of economic growth as well as environmental conservation. Coexisting with these positive values, are negative values. Low level of advanced technology, financial capacity, market network and connectivity account for poor entrepreneurship in indigenous population. Majority of population is still confined to subsistence agricultural economy. Negative values restrict economic growth likely through external agencies investments on one hand and on the other given way to proliferation of exploitative tendencies. Social problems such as male outmigration and human unrest are the manifestation of all these negative values.

3. The Himalayan System - The Setting, Problems and Issues

3.1. The Region

The mountains separating Indian sub-continent along its north-central and north-eastern border, lying within geographical limits of about 26°20' and 35°40' North and 74°50' and 95°40' East are commonly referred to as Himalaya (Ives & Massereli, 1989). It covers fully/ partly eight Asian countries *viz.,* Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal and Pakistan. Though the ancient Indian literature is full of praises for the glory of the Himalaya, this importance is now overwhelmed by the miseries of Himalayan environment and development of Himalayan dwellers in the recent past. Himalaya is crucial in regulating monsoonic climate and ensure adequate water flow in major rivers in South Asia. Thus influences of Himalaya are far reaching. The Himalaya, lying in Indian territory, is spread over a length of about 2,500 kms and a width of 220 to 300 kms. It covers partially/fully eleven States/provinces of India *viz.,* Jammu & Kashmir, Himachal Pradesh, Sikkim, Nagaland, Manipur, Mizoram, Tripura, Meghalaya, Assam, West Bengal and Uttar Pradesh (Fig. 1). Some ranges in north-eastern region are excluded from Himalaya on the basis of geological history and are called as extension ranges of Himalaya. However there appears no significant visible difference between the main Himalayan range and its extension ranges in terms of biological and environmental characteristics. It has a total geographical area of approximately 591 thousand km^2 inhabited by 51 million persons. The region is characterized by sparse population, undulating terrain, farflung small villages difficult to approach, scattered land holdings, shallow and gravelly soil, agro-pastoral economy, scanty irrigation, lack of technological advancements. Himalayan region covered in the State of Uttar Pradesh consists of two sub-regions *viz.,* Garhwal and Kumaon; the two together being referred to as Uttarakhand/ Uttaranchal.

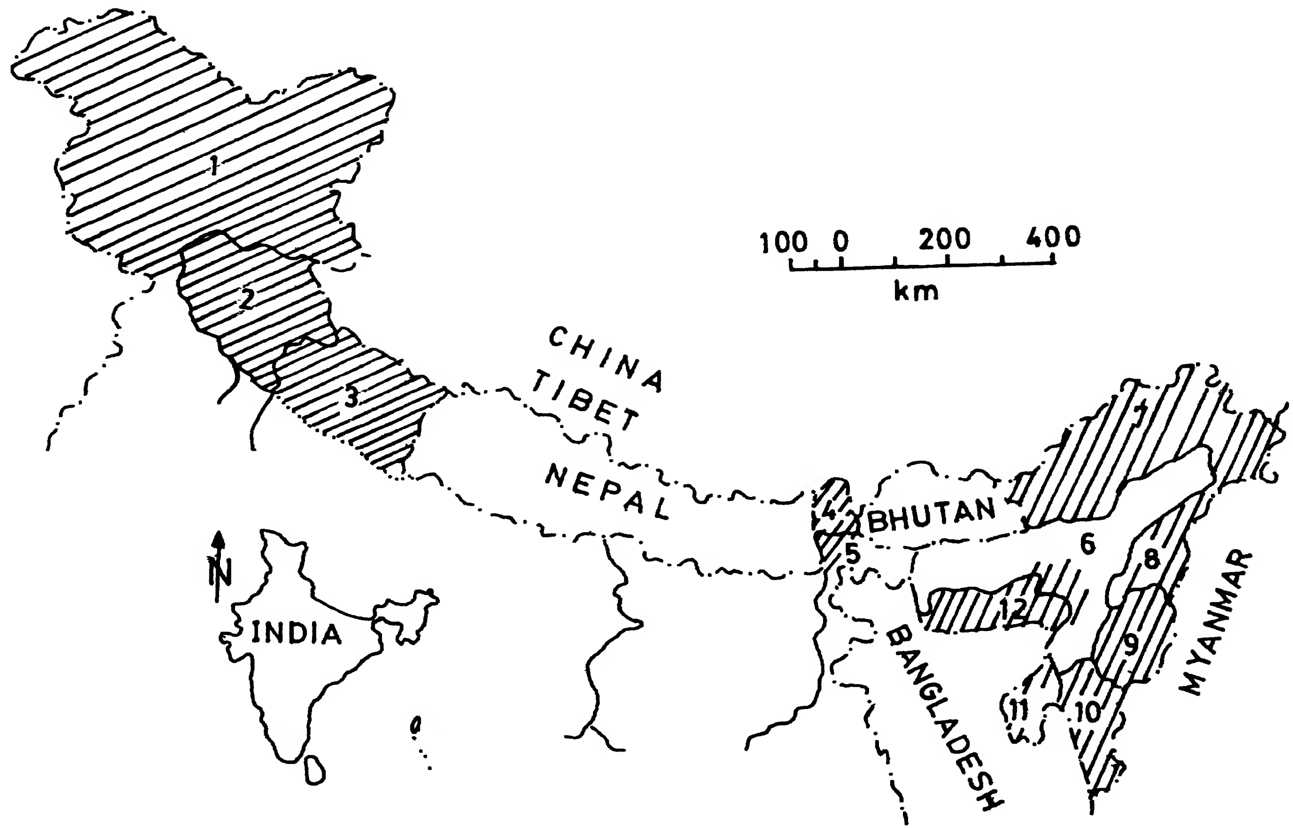


Fig. 1. Indian Himalaya (1-12 are the States/Provinces covered partly or fully in Himalaya; Himalayan mountains are shaded; 1, Jammu & Kashmir; 2, Himachal Pradesh; 3, Uttar Pradesh; 4, Sikkim; 5, West Bengal; 6, Assam; 7, Arunachal Pradesh; 8, Nagaland; 9, Manipur; 10, Mizoram; 11, Tripura; 12, Meghalaya)

In India, hill areas can be divided into two broad categories: (i) self-contained politico-administrative units co-terminating with the boundaries of the States/ Union Territories which have their own Five Year Development Plans to take care of their developmental needs. These are referred to as Special Category States and include Jammu and Kashmir, Himachal Pradesh and Sikkim. The hill areas forming parts of larger composite States occur in States of Assam, Uttar Pradesh, West Bengal. These areas are covered by Hill Area Development Programme, which forms a component of Five Year Development Plan formulated for an entire State. Geographical area covered in the State of Jammu and Kashmir and Himachal Pradesh is commonly referred to as western Himalaya, that in Uttar Pradesh as central Himalaya, Sikkim and Arunachal Pradesh as eastern Himalaya and mountainous areas in other eastern Indian States as north-eastern extension ranges.

3.2. The People

Multiple ethnic composition is a striking feature of Himalayan realm. There are numerous tribal groups confined to the Himalayan region. Population size and distribution of different ethnic groups greatly varies. Among smaller groups, Raji tribe of Kumaon, is represented by only about 350 individuals. Ethnic spectra of central and western Himalaya differs conspicuously from that of the north-eastern region. Racially, a majority of tribal communities, particularly those in north-eastern region, exhibit '*mongoloid*' affiliation as observed from the physical features of the people. In western and central Indian Himalaya, '*Khasa*' ethnic characteristics are more conspicuous. Evolution, migration and acculturation process gave rise to a number of socio-cultural identities representing tribal-non-tribal continuum. It could be generalized that traditional tribal societies, in majority of cases, even at present prefer isolation and preserve their culture when compared with non-tribal groups. However, with gradual improvement in communication and expansion of market economy, the tribal cultures are getting more and more influenced by the values of modernization and westernization.

Assam is the most thickly populated State followed by Tripura whereas Arunachal Pradesh is the most thinly populated province of Indian Himalaya. Urban sprawl is exceedingly high in the State of Mizoram where about 46 % of population is urban. Himachal Pradesh and Sikkim are the least urbanized States. Males outnumber females in all areas, except for rural areas of Uttar Pradesh Hills and Himachal Pradesh. States in the north-eastern region have achieved a higher level of literacy as compared to those in the central and the western Himalaya.

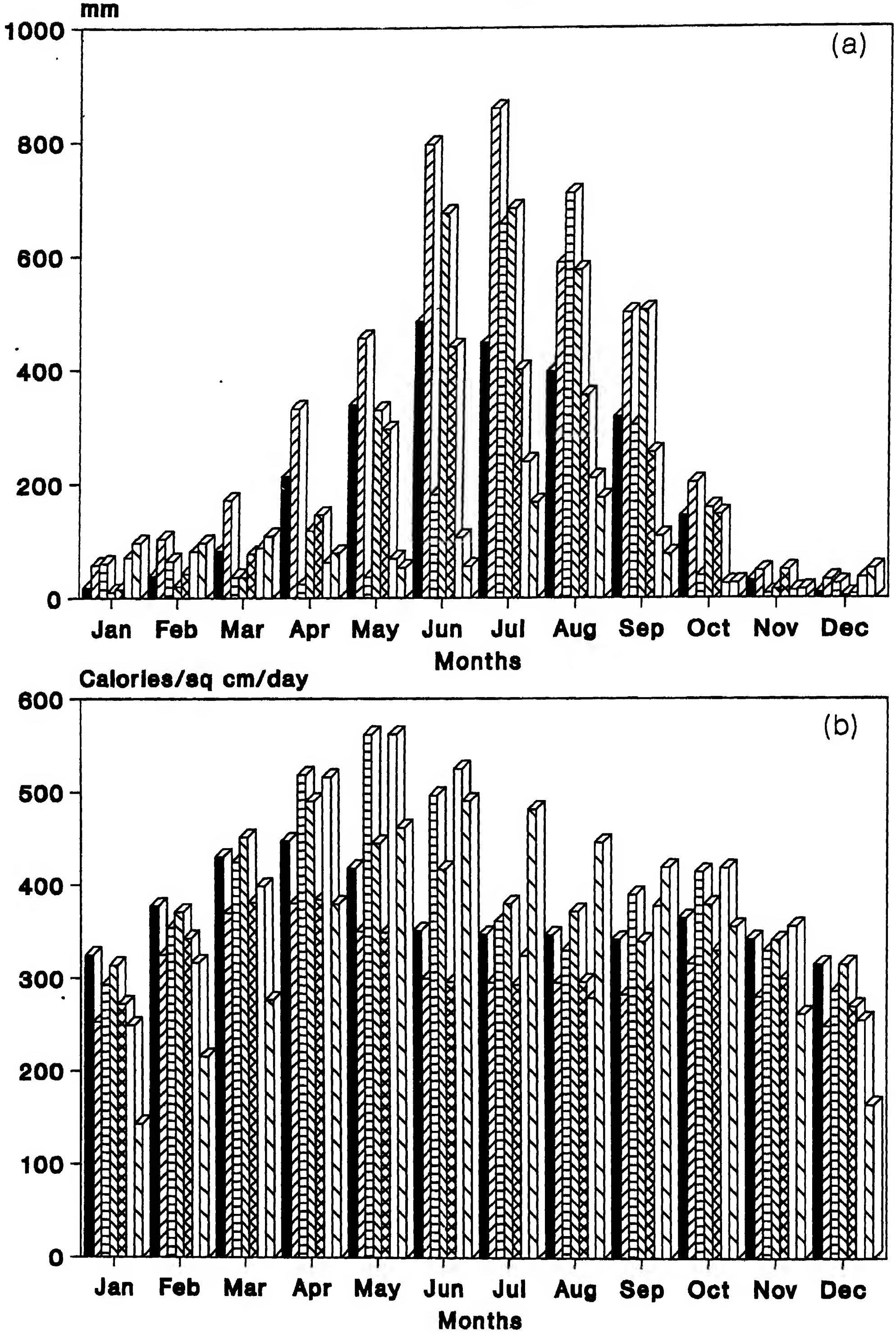
other works.

3.3. The Climate

Latitude, altitude and continentality are the most influencive factors regulating the climatic attributes over large areas in the mountains. Effectiveness of the regional determinants is moderated by the local topographical influences (Barry, 1992). Himalayan Mountain System instead of running parallel in the east-west direction, runs from north-west to south- east direction. The western ranges of Kashmir are located around 36°N while the eastern ranges of Arunachal Pradesh are located around 27°N. Thus, western region including the mountainous areas of Jammu & Kashmir, Himachal Pradesh and Uttar Pradesh are more temperate compared to eastern sector including Sikkim and Arunachal which for being closer to the equator exhibit more tropical influences. Because of proximity of the eastern Himalaya to the sea (Bay of Bengal) and the unique directions of monsoon originating from the Bay of Bengal and Arabian Sea, the eastern Himalaya receives more rainfall when compared with the central and the western Himalaya. The topographical/ geomorphological variations do not straightway correlate with the latitudinal or continental trends. Indeterminate configurations of valleys and peaks with respect to their length, breadth and altitude result in immense variation in climatic attributes over short distances. Average annual rainfall was found to vary from 1800 to 2600 mm over an area of 30 km^2 in Sikkim Himalaya (Sharma *et al.*, 1992). Since latitudinal, continental and orographic factors influence the climate in different ways, altitudinal gradient in climatic elements (Baumgartner, 1980) is not likely to be the same all across the Himalaya. While topography of the region has been mapped with sufficient detail, quantitative information on rate of air ascending over a mountain slope, water vapor supply, wind direction and wind speed which determine the precipitation regime (Browning, 1980), are lacking.

In general, a seasonal monsoon climate characterizes the entire region. Climate gets warmer and humid from the north-west to the north-east Himalaya. In a given latitudinal zone, climate gets cooler with increase in altitude. It could also be broadly generalized that total precipitation increases with elevation, and so also the proportion of snowfall and hails. Major climatic attributes of some locations across the region are given in Figure 2. Because of latitudinal effect, snow line is encountered at a much higher elevation in the north-eastern Himalaya than in north-western Himalaya. Hailstorms, avalanche, cloud burst, lightening are common all through the region, more so in the higher altitudes.

The available measurements of Carbon dioxide concentration in Garhwal/ Kumaon reveal that the high altitude areas (3000 m amsl) are characterized by pre-industrial levels of carbon dioxide concentration (270 ppm), whereas in valleys (500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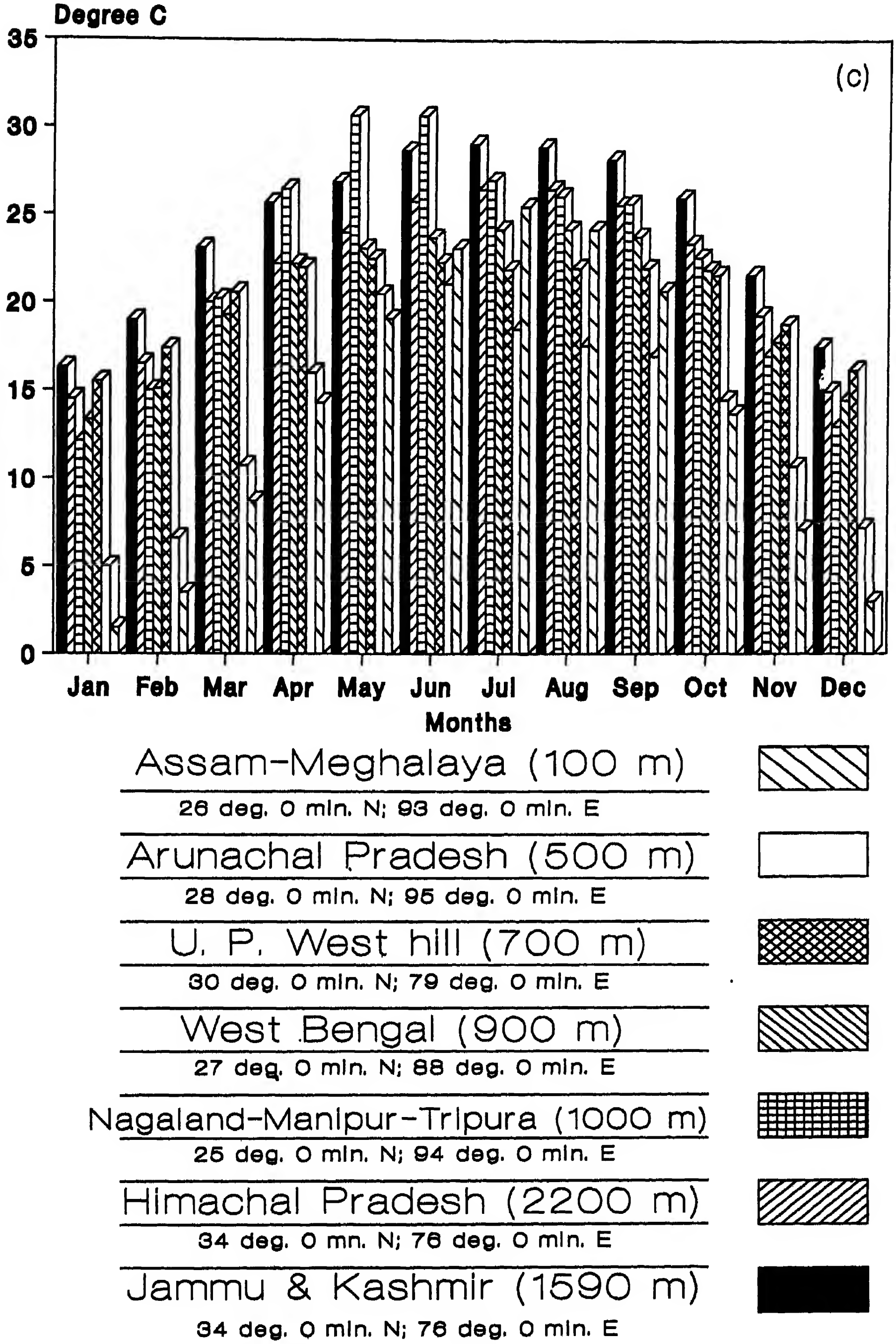

Fig.2. Major climatic attributes (a) rainfall, (b) global radiation and (c) mean temperature) of some locations across the Himalaya (Source: Anonymous, 1987)

m elevation) the concentration (330 ppm) compares well with the present day global averages. The differences in other atmospheric parameters like air density across an altitudinal gradient resemble the generalised global trends. The influence of industrialization in terms of chloroflourocarbons (CFC) emission is expected to be negligible as difficult topography restricts industrial growth. Deforestation could be responsible for changes in the Himalayan climate but the state of knowledge on the rates of deforestation and reforestation is so confusing (Saxena *et al.*, 1993) that it is difficult to establish reliable forest - climate relationships.

3.4. The Geology

Himalaya is a unique geofeature of the planet. Himalaya is considered to be the youngest mountain system of the earth formed as a result of collision of Indian plate with Tibetan plate. Plate tectonic movements have continued and get manifested as high seismicity, slope failures and massive erosion in the region. While precise prediction of the episodic hazardous events like earthquakes and slope failures are not possible, there are arguments and evidences suggesting that man induced activities like removal of tree cover, annual crop cultivation on steep slopes and engineering works on the slopes neglecting geoenvironmental attributes become counterproductive to the long term objectives of sustainable development. Susceptibility to geological hazards varies considerably within the region. Though difference of opinions prevail on geographical boundary of the Himalaya (Risal, 1993), based upon geological considerations, Himalaya is divided into distinct zones *viz.*, Shiwaliks, Lesser Himalaya, and Greater Himalaya running as parallel northwest-southeast belts (Valdiya, 1980) (Fig. 3).

i) Greater Himalaya (Himadri):

The northern most ranges of Himalaya separated by the "Main Central Thrust" constitute Greater Himalaya (Himadri) zone. The feature is full of glaciers, snow clad peaks and large longitudinal valleys. This range has a granitic core flanked by metamorphosed sediments. Its' width and altitude varies between 40-60 km and 5000-7000 m elevation, respectively.

ii) Lesser Himalaya (Himanchal):

This is a central chain of mountain ranges enclosed by the divides of the "Main Central Thrust" in the north and "Main Boundary Thrust" in the south. The rocks are highly compressed and altered. The region consists of higher mountains cut into deep ravines. Altitude, in general ranges between 5000 m to 1000 m elevation and width between 60-90 km.

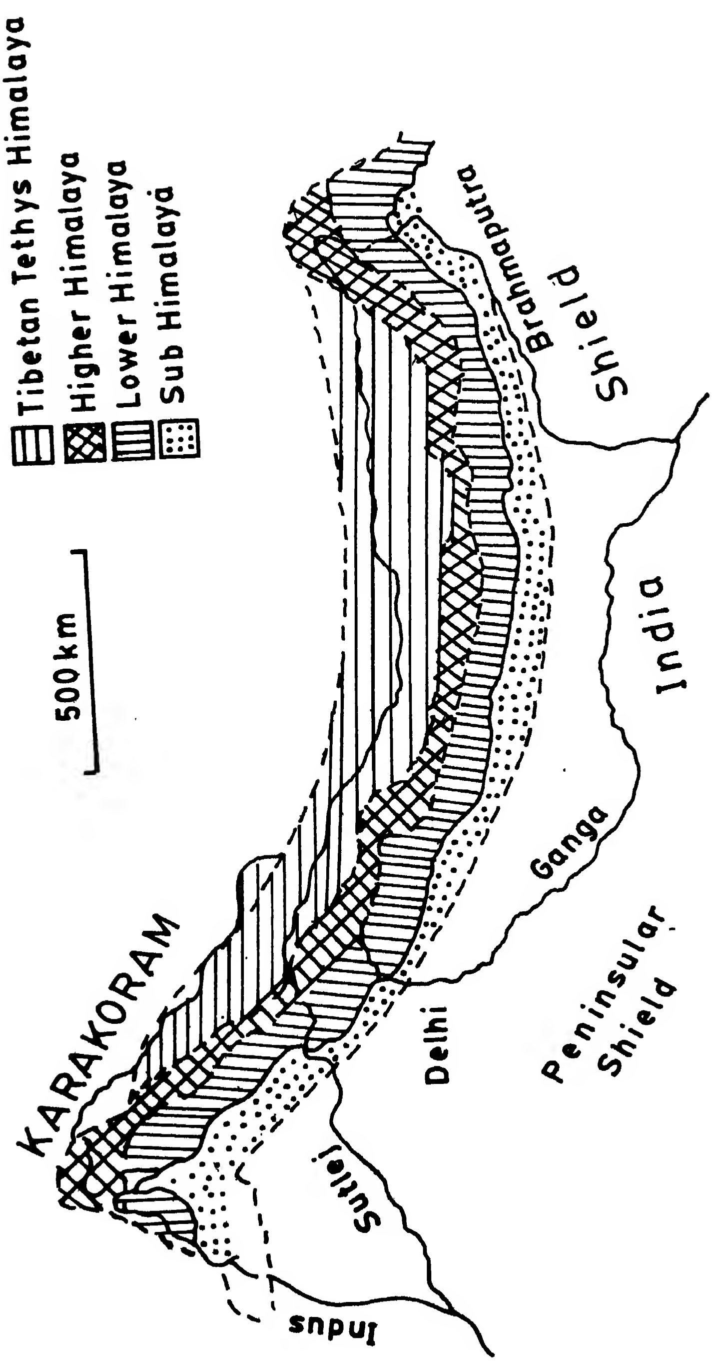

Fig.3. Geological Zones of Himalaya

iii) Sub-Himalayan Tract (Shiwaliks):

The foothill belt of the region is built entirely of Shiwalik sediments. These newer and river borne deposits derived from the rising Himalaya represent the most recent phase of the Himalayan orogeny. These hills generally exhibit a hogback appearance where the southern slopes are steeper in comparison to the northern slopes. The wide longitudinal valleys in between the lesser Himalaya and the Shiwaliks are called "*Duns*" in western and central Himalaya and "*Dwars*" in eastern Himalaya. This region is characterized by fault scrap, anticlinal valleys and synclinal ranges. The width, varies between 5-30 km and elevation between 300-1000m.

3.5. Problems and Issues of the Region

3.5.1. Deforestation

Degradation of natural forests is a global problem (Guppy, 1984; Sayer & Whitmore, 1991). Humans have been destroying forest for millennia ever since agriculture was discovered (William, 1989). In the Himalaya too, deforestation is argued to be not a recent phenomenon. It has a long history, being well established in the late eighteenth century at least (Mahat *et al.,* 1986). In the Himalaya, degradation of forest cover is a primary problem which gives way to many others. Deforestation of hill slopes accelerates many environment degradation processes like soil erosion, slope failures, depletion of soil fertility, scarcity of fuelwood and fodder, increased overland flows, reduced ground water recharge and loss of biological diversity. Siltation of river beds in lowlands arise out of forest cover degradation in the Himalaya. However, the extent of impairment of various processes attributed to forest degradation depends upon a range of other factors including past histories, intensity of removal of natural vegetation, patterns of natural regeneration and/or other human interferences (Valdiya & Bartarya, 1989 & 199; Singh *et al.,* 1984; Gilmour *et al.,* 1989; Ramakrishnan *et al.,* 1992; Alford, 1992). Definition of 'forest degradation' (deforestation is the extreme stage of forest degradation causing removal of tree cover at any given point of time) and lack of a temporal data base of land cover/use, projections on rate of deforestation may give misleading scenarios. Land cover classification schemes applied in the Himalayan region (Table 2) illustrate the variability in perception about what forest or forest degradation is. Varying definitions and inconsistent methodologies adopted for assessing land use result in a wide range of variation in forest area estimates as shown in Table 3. How far interpretations drawn from available data could be misleading, is illustrated from the data pertaining to central Himalayan region (U.P. Himalaya). Glancing at the data without going into methodological details, would lead one to draw the conclusion that forest cover increased by 1.4 fold during 1972-1982 (Saxena *et al.,* 1993). Contrary to this, a concern for 'ongoing deforestation' has been expressed during the

Table 2. Forest/vegetation classification schemes adopted by different agencies/authors

Anonymous (1983)	Anonymous (1989a)	Kawosa (1988)	Singh *et al.*, (1984)	Singh (1987)
Closed forest	Dense forest (crown cover >40 %)	Forest (continuous canopy), (crown cover >60 %	Good forest (crown cover >60 %	Closed forest (canopy cover >50 %
Open/degraded forest	Open forest (crown cover 10-40 %	Forest vegetation (crown cover 40-60 %)	Medium forest (crown cover 30-60 %)	Open forest (canopy cover (Canopy cover 20-50 %)
Non-forest (including agricultural land, grass land, shrub land, non-forest plantation, barren land)	Scrub area (crown cover <10 %)	Forest vegetation (crown cover <40 %)	Poor forest (crown cover <30 %)	Scrub
	Non-forest (including agricultural land, grass land, shrub land)	Alpine meadowns, High altitude blanks	High altitude meadows	Grass land
Others (including snow, fog, cloud & shadow)	Non-forest plantation (barran land)	Glaciers or permanent	Snow	Shifting cultivation
	Uninterpreted areas (clouds, fog & shadow)	Non-vegetation areas	Other non-forests	Regrowth (2yr old) Bare soil

same period. The confusing state of data base thus lead to erroneous conclusions, particularly on the pace of deforestation or forest degradation.

Unsustainable trends in forest resource dynamics result from two factors - economic pressure imposed by market demands of timber/ other forest produce in prosperous lowland areas and subsistence pressure imposed by a strong dependence of mountain societies for securing their livelihood. Relative impacts of these factors in the Himalaya is a controversial issue (Ives & Massereli, 1989; Saxena *et al.*, 1993). Unsustainable forest resource use seems to have proliferated in the past more under the pressure of economic gains than under the pressure of subsistence needs of the local population. Exploitation of forest capital by the colonial rulers exceeding the regeneration potential for a period of about two centuries till 1947 has caused considerable damage. After colonial rule ceased to exist, economic development incentives did prevail till Forest Conservation Act came into force in 1980. Indian Forest Policy as at present clearly places priority on environmental values of forests and sustainable forest - man linkages (Anonymous, 1992a). Threats of unsustainability are now likely to be more due to institutional bottlenecks in honoring the spirit and goals envisaged by the State. Differing climate regimes support differing vegetation types.

Table 3. Forest area estimates for Jammu & Kashmir State - variability in data reported by different agencies

Reporting agency	Forest area (X 10^3 ha)
Anonymous (1976)	2761.00
Anonymous (1980a)	2104.00
Anonymous (1982)	2089.20
Anonymous (1983)	2235.50 *
Gupta (1983)	2801.60
Kawosa (1988)	1317.60 **
Prajapati (1989)	2088.00 ***

* data for the year 1972-75;
** data for the year 1980-82;
*** data for the year 1981-83.

In a given altitudinal zone, natural vegetation is more dense, diverse and stratified in the north- east than in the north-west. On account of being close to South-east Asia, South-east Asian tropical plant species are more abundant in the north-

eastern Himalaya and gradually decline towards north-west. Temperate coniferous elements and tropical African elements decrease from the north-east to north-west. Cooler and drier climate of north-western Himalaya supports a rich germplasm of temperate fruits while hot and humid climate in the north-east supports a rich germplasm of tropical fruits like citrus. Himalaya, though it occupies 15 % geographical area of the country, nurtures 28.8 % of the endemic dicot flora of the country (Chatterjee, 1939). Considering the status of survey and documentation of genetic wealth of the difficult mountainous areas, the biological richness (in terms of number of species) of the area is perhaps underestimated. Deforestation threatens unrecoverable losses of biological diversity of the region.

3.5.2. Declining Yields and Food Insecurity

Expansion of agriculture on marginal land and declining crop yields are considered to be major unsustainable trends in the Himalaya (Eckholm, 1979; Ives & Massereli, 1989; Jodha, 1990). Similar to deforestation/forest degradation scenario, there is a lack of adequate data base supporting these agricultural trends. Temporal trends can be established conclusively from reliable and comparable time sequence data which are unfortunately lacking. Consistent increase in cropland acreage in response to population expansion will hold true only when there is no change in the attitudes of the farmers and that of agricultural technology. An upward trend in preference for secondary and tertiary sector development activities might have deteriorated agricultural production in the region. The alternative explanation is that the mountain people are forced to abandon their agricultural land and search for alternative modes of securing livelihood because mountain farming systems no longer provide food security. It is only in the last few decades that food grains have become a market commodity in the hills. This change commonly forms the basis for drawing the conclusion that food grains are marketed because of local food insufficiencies. Interpretations and generalizations based on indirect evidences together with visualizations are bound to lead to unrealistic impressions. It is difficult to resolve whether poor performance of agriculture is due to decline in acreage of productive land or due to decline in crop yield levels.

Erosion of genetic diversity of traditional crops and role of change in food habits in aggravating food insecurity problem in mountains are as yet not considered as important as expansion of cultivated cropland and low levels of crop yields. Crop yield data at two points of time in Uttar Pradesh Himalaya (Table 4) suggest that yields of traditional food crops like finger millet, paddy and Echinocloa have been more stable than wheat. Unfortunately, human preferences for consumption of wheat and paddy, more so of paddy, are recent changes in the food habit. Thus food insecurity problem realized at present is likely to be in part due to change in food habit and population growth rather than only due to decline in yield levels.

Table 4. Estimated yields of agrarian crops in Kumaon (kg/ha)

Parameter	Rice	Wheat	Barley	Fingermillet	Echinocloa
1896	1120	898	NA	1120	1100
1979	1133	538	362	924	924

Source: Whittaker, 1984; NA, data not available

Emergence of land use changes is a continued evolutionary process set in from the beginning of advancement of human civilization. Remoteness, inaccessibility and frequent environmental risks in mountains fostered evolution of production systems sustained by locally available inputs, rather than through external inputs. In a historical perspective, hunting and gathering from the wild was the starting step for securing survival. This gave rise to shifting agriculture followed by settled agriculture. Shifting agriculture continues to be the major agricultural system on the forest slopes in north-eastern tribal belts, while its occurrence in the central and the western Himalaya is at present rare. Settled agriculture on terraced slopes in mid elevations (upto 1800-2000 m elevation) or unterraced gentle slopes in high elevations (above 1800-2000 m elevation) is the major agricultural land use in the central and the western Himalaya. Diversity of domesticated crops in the region is very high when compared with low land agricultural systems. Crop diversity is managed by mixed cropping and/or with crop rotation. Valleys all through the Himalaya are much more intensively cropped than the slopes. Technological innovations such as chemical fertilizers, pesticides and high yield crop varieties which transformed low land agricultural areas, could not penetrate the mountain farming system to the same extent, on account of topography. Dependence on forests for maintaining soil fertility in crop lands or expansion of agricultural land itself thus was not substituted through new technologies. As forests and livestock provide material and energy inputs into traditional mountain farming systems, expansion of traditional agriculture runs the risks of forest degradation. In order to meet the present and future challenges and for meeting sustainability criteria, the traditional systems need to be adapted in ways which enhance crop yields but not at the environmental and social costs (Ramakrishnan *et al.,* 1993).

3.5.3. Declining Livestock Productivity

Of the 449 million domestic animals in the country, nearly 50 million are in the Himalayan region. Cattle are the most common (47.5 %), followed by buffalo (12.3 %), goats (15.8 %) and sheep (10.4 %) (Fig. 4). Generally, cattle, goats and

sheep constitute the important livestock wealth in the western and the central Himalaya whereas pig and poultry are the ones in the eastern Himalaya. Yaks are reared in alpine areas. Equines are reared for transportation. Overgrazing and open grazing are often considered to be the major causes of poor regeneration in degradation of forest areas. This view is substantiated by the fact that livestock density per unit of land area in the Himalaya is much higher than in the lowlands and by the lack of exclusive fodder crop farming in the mountains. Positive values of traditional livestock management systems have been given marginal importance. Efforts for diffusing grazing pressure on land in local animal husbandry systems do exist. Invariably, livestock are sent to high altitude pastures during summer/rainy season. A significant portion of the animal feed is derived from crop wastes. Thus hill people are conscious of the consequences of overgrazing. Nevertheless, a trend of increasing pressure of livestock on the forests cannot be denied. Comprehensive comparisons of the ecological/economic costs/benefits of rearing livestock in the Himalaya with those in other environments are lacking. The land holdings being very small, livestock supplement the income and are considered to constitute capital asset.

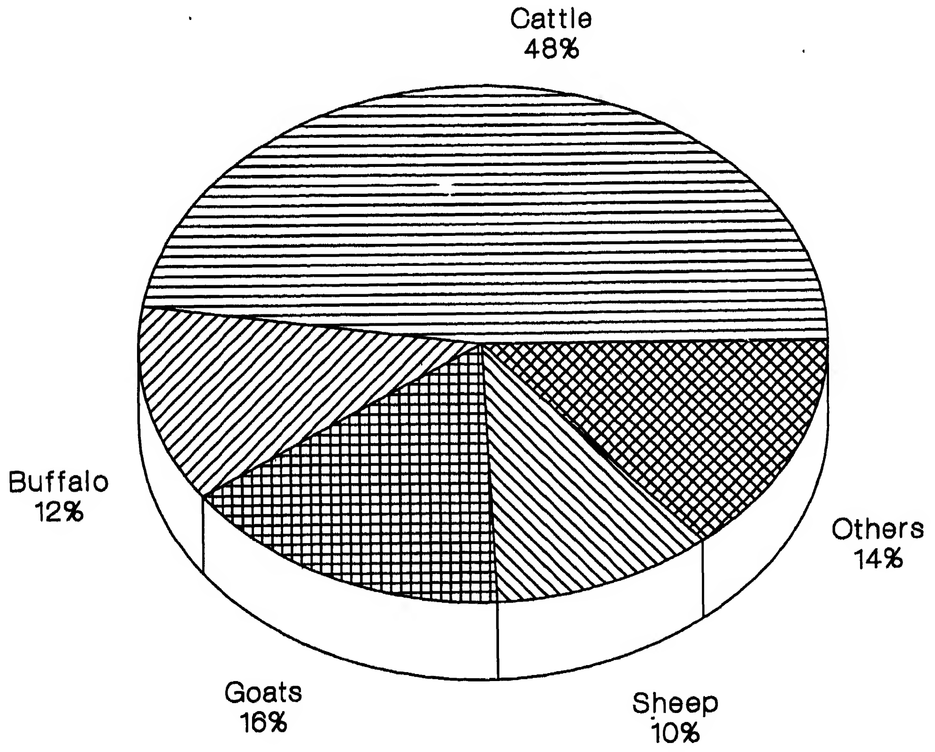

Fig. 4. Livestock population in Himalaya

3.5.4. Horticulture

Horticulture is a more recent land use change which has succeeded in selected sub-regions, particularly Himachal Pradesh and Kashmir in the west. A change from traditional food crop cultivation to agro-horticultural systems succeeded largely because of economic incentives and monetary profits to the farmers ensured through government subsidy and market demands. Horticultural development in the central and the north-eastern region is so far not as conspicuous as in the western Himalaya. Perennial cash crops other than fruit trees do play a vital role in economy of eastern and north-eastern Himalaya. Large cardamom grown as an understory crop in the forested areas is an important perennial cash crop in Sikkim. Citrus, tea, rubber and pineapple are the major cash crops of the north-eastern region.

Environmental and social costs of horticultural development are now being increasingly realized. Horticultural land use expansion often involves encroachment on forest land. Demands for packing the marketable produce becomes a pressing factor for unsustainable harvests from the forest land. Market forces and institutional set-up created for gearing up horticultural development led to economic growth but at the cost of equity. Prosperous farmers benefited more than small and marginal farmers (Swarup & Sikka, 1987). Tea, coffee and rubber cultivation in the north-eastern Himalaya did contribute substantially to economic development of this region, but also gave rise to social tensions between the migrants and the locals. Social and environmental costs of these commercial production systems promoted directly or indirectly by the Government were unfortunately perceived only long after the initial phase of economic growth. There are a number of wild trees, shrubs and herbs which supplement the nourishment of people in the hills. The knowledge of their uses and productive potential is declining. Reasons for this decline are many including absence of market, lack of tested technology of their cultivation and value addition, and weak public policies promoting use of wild edibles.

3.5.5. Hydrological Imbalances and Soil Erosion

Water is the most underutilized, at the same time the most abundant resource of the Himalaya. It is estimated that about 11,00,000 million m^3 of water flows every year down the Himalaya offering a potential for generating electricity to the tune of 28,000 MW and making as much as 247,000 million m^3 water available for irrigation in the Indo-gangetic plains (Valdiya, 1985a). Uneven distribution of water both in space and time comes in the way of harnessing this potential for development. Flow of water as a result of gravitational force provides immense scope for power generation and improving upon the efficiency of agricultural systems in the region. At the same time, a short sighted approach of harnessing this renewable resource may

result in social problems, waste of financial resources and environmental hazards engulfing the plains too.

There are subsurface and surface flows which largely meet the demands of hill. Ground water use is confined to large low land valley areas only. Despite a surplus potential water resource and hydropower, scarcity of this resource in the form of a short supply of drinking water, rainfed farming and low level of electrification are common in many areas. The nature and magnitude of the problem however is not uniform all through the region. To illustrate, 100 % village level electrification has been achieved in Himachal Pradesh. Hydroelectric potential in this region has been exploited to such an extent that the State of Himcahal Pradesh produces enormous surplus. The State has to sell surplus power outside the State at nominal cost and thus is unable to realize potential benefits. Other problems, pertain to management of power production and transmission. In many remote rural areas, power supply is so erratic and there is so much variation in voltage that the rural poor find the new source to be no way better than the conventional energy sources. Contrary to the situation in Himachal Pradesh, hydroelectricity production in other States lags far behind their own requirements.

Water availability for essential needs (like drinking water, sanitation) and for productive uses (like irrigated farming) is far from adequate. About 84 % of the net sown area in the Himalaya is rainfed. Though water stress limiting productivity is not true for the high altitude areas, unstable and low levels of crop yields on slopes in mid and low altitudes (upto 1500 m elevation) are often due to water stress. Incidence of reduced discharges and drying up of springs (the traditional sources of drinking water supply) have been found to have increased during the past few decades (Valdiya & Bartarya, 1991). Though there are no controversies on such trends, effectiveness of natural and human factors contributing to hydrological imbalances has emerged as a contentious issue in recent years (Gilmour *et al.*, 1989; Valdiya, 1985b; Alford, 1992; Smadja, 1992). Corrective measures have been taken but seem to suffer from several drawbacks. Development interventions introduced by the Government since 1950s failed in resolving drinking and irrigation water supply problems partly because of technological drawbacks and partly because of weak institutional arrangements made for transfer and management of the introduced technology (Kothyari *et al.*, 1991).

Sustainability of megalevel water resource development projects addressing triple objectives of drinking water supply, irrigation and hydroelectricity generation together involving heavy investments, extensive environmental changes and requiring long gestation periods before benefits accrue have been questioned. Economic cost:benefit ratio and rate of financial returns of these projects is also questioned on account of poor precision of parameters used for deriving economic indices. To

illustrate the case of one multipurpose river valley project in central Himalaya, variation in data on sedimentation rates was found to vary from 8.1 ha m/100 km^2/year to 16.5 ha m/100 km^2/year (Table 5). This led to over two-fold variation in estimated values of life span of the reservoir (62-160 years) and consequently benefit/cost (1.28-3,96) ratio of the project. Sustainability of these projects is also questioned on accounts of geological and geomorphological features of the Himalaya. To what extent a given location would offer sustainable development opportunities or render the exercise unsustainabile becomes an issue of debate (Valdiya, 1985b; Chandra, 1992). Other concerns attracting more and more attention with increasing emphasis on environmental and social goals of development are questions of benefit sharing between the mountain and lowland people and capacity/risks to recover environmental and social costs (Saxena & Rao, 1994, 1995).

Development interventions at micro-level, considering drinking water, irrigation, hydroelectricity generation in an integrated manner have yet to be properly designed and tested. Decentralized and small scale management systems involving active people's participation and adapted to mountain constraints appeal as more sustainable, particularly for meeting the minimum needs of the marginal areas. Traditional management of irrigation and potable water did not involve any advanced technology. Its value and efficiency lie in low levels of financial investment, local controls, quick responses in taking corrective actions in the event of damages. Disregard of these traditional management considerations adapted to mountain environment limits the operational success of advanced technologies.

Table 5. Variability in data on sedimentation.

Data Source	Estimate on sedimentation (ha m/100 km^2/yr)
Project Authorities	8.10
Central Water Commission	12.50
Ganga Discharge Organization	16.53
Central Water Commission	14.86
Project Authorities	14.50

3.5.6. Land Abandonment

As a consequence of the uneconomic production from inconveniently located agricultural plots, and growing alternative off-farm opportunities for securing livelihood, a significant portion of farm land has been abandoned. Such a situation

also reflects out-migration from the rural areas of the hills, and at the same time, the unwillingness of the absentee owners (non-resident) to part away with the land. Land abandonment under these conditions leads to a decline in the overall productive potential of the land. Adaptive responses to stress factors by farmers (Scott & Walter, 1993) have played a significant role in the evolution of traditional agriculture in the past when farming was the only option for securing livelihood. In the present circumstances, it often becomes more cost effective for the farmers to find alternate employment than to expend his costly and scarce resources for rehabilitating the land of low productivity (Turner, 1982, Singh & Singh, 1987). At present 30 % of the total reporting area of the Indian Himalaya is classified as fallow, non-cultivable and unculturable land (Fig. 5). Besides, a significant acreage of land classified as forest land lacks tree cover. Since natural regeneration in these areas is extremely slow, for all practical purposes, the acreage devoid of tree cover or of poor grazing value could be considered as abandoned land.

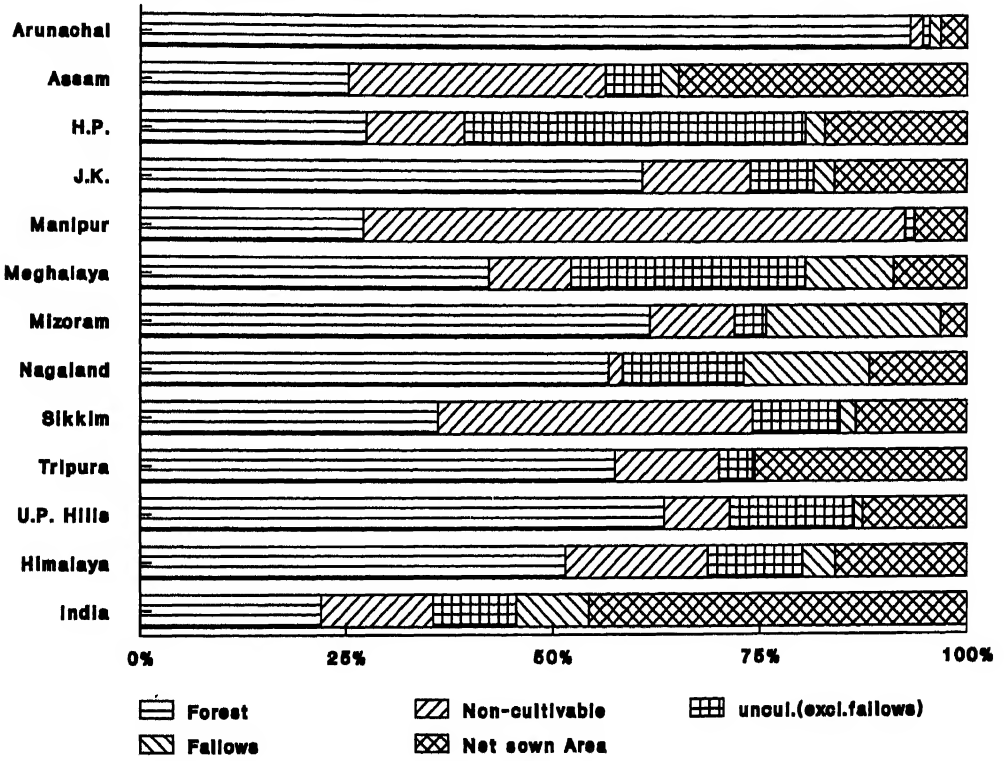

Fig. 5. Land use pattern in Himalaya

Acreage of areas classified as fallows and uncultivable land excluding fallows in the available statistics at regional level are indicative of the magnitude of land abandonment problems. In States like Himachal Pradesh in the west and

Meghalaya in the east, more than 30 % of the reporting area is classified as uncultivable land. Fallows mean land abandoned for a period of a few months for restoring soil fertility through natural processes. Utility of these areas could be enhanced by raising the cropping intensity. Uncultivable land excluding fallow category covers the land suffering severe physical constraints. Under extreme situations of food scarcity farmers are likely to extend cultivation in these areas but the cost of their rehabilitation is very high. Primary motive behind extension of agriculture into these marginal areas relates to a tendency of increasing the land holding size and not that relating to food security.

3.5.7. Population Growth

Decadal population growth rates calculated for each of the Himalayan States for the period 1951-1991 indicate that the growth rate has slowed down, though marginally in most of the cases. However, it is still above the national average in all States except for Himachal Pradesh and Uttar Pradesh Himalaya (Fig. 6). Average size of land holdings in the Himalaya is about 1/8th of the average for the country. However, smaller size of land holding is not solely due to population growth. A large chunk of land is either kept away for non-agricultural use *e.g.,* forest, or is not suitable for agriculture *e.g.,* rock out crops, perpetual snow areas. The proportion of the of land not available for cultivation because of physical constraints and legal constraints in the Himalaya is of a much higher order than that in the plains. Population pressure, beyond the carrying capacity or population support capacity of the region, can disrupt the balance of utilization/regeneration. As a result of scarcity of a given resource or a set of resources due to increase in demand, it is also possible that innovative technologies and/or human/institutional mechanisms enhance the rate, the regeneration potential of that resource or curtail the level of consumption of the scarce resource or lead to emergence of substitutes of the scarce resource (Fleuret & Fleuret, 1978; Fox, 1993). However, lack of evidence in support of positive changes resulting from population growth in the Himalaya is suggested to support the widespread view that population pressure leads to unsustainable trends in the region.

Forest area and human population data of States in the Himalayan region indicate (Table 6) an increasing trend of population growth and decreasing trend of forest area. However, there seems to be no statistically significant relationship between the two parameters. Nagaland, a state where the rate of population increase is observed to be the highest, shows the lowest degree of deforestation. Manipur, Meghalaya and Tripura exhibit more or less similar rates of population growth but differ considerably with respect to the loss of forest cover during the same period. Data on forest cover and population size merely at two points of time are indeed inadequate for drawing any precise trends or relationships. Further, demands on forest by the increasing population may not necessarily get expressed as deforesta

tion in its true sense. While there are deficiencies in the methodology adopted for deducing these relationships, the observations do suggest that (a) population explosion alone is not responsible for the current scenario of forest degradation, and (b) unrealistic picture may emerge if attempts are made to predict the future scenario based upon the available data. Overpopulation, a major factor contributing to environmental degradation and poverty in many developing countries and also implied for the Himalayan region (Martins & Nautiyal, 1988; Ives & Massereli, 1989) need to be looked into from a variety of angles and considering multiplicity of interacting factors. Concepts of population support capacity or carrying capacity are not clearly established in quantitative terms. Carrying capacity statistics projected in terms of sustainable limits of population density or livestock density arrived at are based on several assumptions and so are likely to be divorced from realities.

Table 6. Forest area ('00 ha) and human population ('000) in some States in the Himalayan region.

State	Forest area[1]		Population	
	1972-75	1980-82	1971[2]	1981[3]
Assam	21055	19796	14625	19896
Himachal Pradesh	15075	9130	3460	4280
Jammu & Kashmir	22335	14361	4616	5987
Manipur	15090	13572	1072	1420
Meghalaya	14390	12458	1011	1335
Nagaland	8154	8095	516	775
Tripura	6330	5183	1556	2053

[1] based on Anonymous, 1983;
[2] based on Anonymous, 1971;
[3] based on Anonymous, 1981.

3.5.8. Alienation and Desperation

Land tenure/ownership laws and regulations usually are considered to be biased State enforcements restricting or denying the age old customary rights and privileges to people, pertaining to the resource use in vast forest land owned by the Government. Such a thinking gives a sense of alienation of the people and leads to people-government conflicts. Because of this perpetual conflict, unsustainable resource use patterns emerge as infrequent retaliatory or opportunistic instances in pockets where Governmental checks are weak.

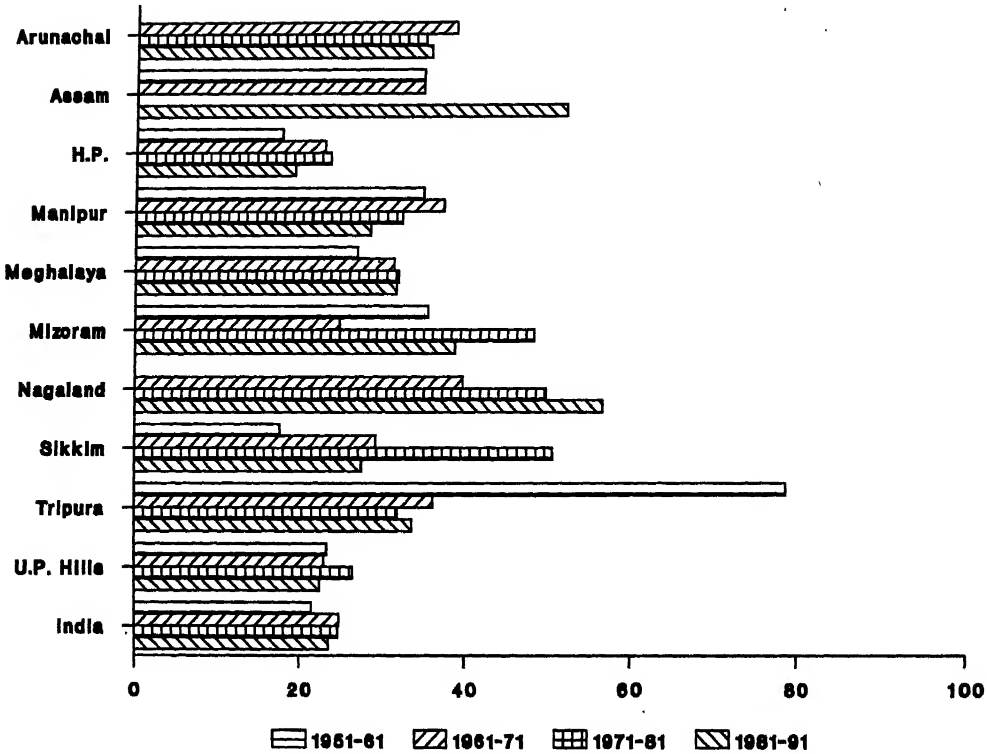

Fig. 6. Decadal population growth rates of Himalayan States

Poor infrastructure and difficult terrain impede industrial development of the area and thereby result in low employment potential for the local people. Though the region is naturally endowed with enormous potential of raw material, concentration of processing facilities for the produce elsewhere debars the Himalayan dwellers in getting a significant share in the accrued benefits. Mass migration from many areas is one of the manifestations of desperate and alienated feelings. There are instances in Garhwal Himalaya where more than 3/4th of the families migrated out of some of the villages during the period 1972 - 88 (R.K. Maikhuri, Personal communication/ unpublished).

3.5.9. Climatic Changes

With the existing state of knowledge, it is difficult to answer precisely questions relating to climate changes in the Himalaya such as, (i) what would be the directions of ecosystem change? (b) at what rates will the changes occur? (c) will the direction and rate of change be uniform and similar across the region, if not which

are the ecological situations where the changes are likely to be drastic? However, the general predictions as conceived by us for the Himalaya are shown in Table 7.

Table 7. Predictions of the direction of change in vegetation in Himalaya initiated by climatic change (Purohit, 1991).

Growing seasons shift to autumn - winter - spring - summer.
Growing season extended, particularly at high altitudes.
Overall, higher level of plant production.
Species currently restricted to valleys will colonize in higher reaches.
Species with predominantly lowland distribution will expand to higher altitudes.
Species with isolated populations on damp north-facing slopes will be threatened.
Bryophytes and ferns will be particularly vulnerable and south facing slopes will become more xeric.
Species with a northern distribution limit will advance northwards.
Species with a southern distribution limit will retreat northwards.

The earth surface patterns and processes may play a significant role in regulating vegetation redistribution and reorganization triggered by climatic changes in the Himalaya. High altitude tree species like *Abies, Acer, Betula* dominate under cold climate because of their adaptation to extreme winters. Rise in temperature would result in competition with new arrivals. High altitude tree species may disappear or move upwards if they fail to coexist with the new entrants. The expected higher level of production in a CO_2 enriched environment can be maintained only when minerals and water do not limit the assimilation of carbon. It would be the mineral- moisture-carbon interaction which will determine the status of ecosystems under the changed climate.

As at present, crop production is limited by cool temperature and prolonged winters in the high hills and by moisture stress in the low and mid-hill region. According to predicted changes, a 1^0C increase in the mean annual temperature would tend to advance the thermal limit of cereal crops in mid-latitude northern hemisphere by about 150 - 200 km, and to raise the altitudinal limit to arable agriculture by about 150 - 200 m. Therefore, release from temperature stress is expected to increase crop production as well as cropped area in the high hill zone. Agricultural scenario in the mid- and low-hill zones would depend upon whether increase in evapotranspiration demand as a result of temperature rise is balanced by the increased precipitation. If the area remains largely under rainfed agriculture as at present and increase in precipitation fails to accompany warming, agriculture potential of most thickly populated mid and low-hill zone is likely to be lowered.

Though in the global context, future warming is invariably argued to cause negative impacts, the Himalaya, considered in a regional perspective and as a distinct geographical entity, may offer a few positive environmental features such as a more hospitable climate for plant growth in high- and mid-altitudes. However, to exploit these positive aspects, science and technology inputs as well as a change in the resource management systems would be needed.

Current land use policies in the region emphasize upon an increase in the forest land arresting agricultural expansion. It would not be the forest area but the dynamics and use of forest resource which could be manipulated to reduce the atmospheric load of carbon dioxide. Forests would act as carbon sinks but only as long as they are actively growing. A large acreage in the region, classified as degraded land, if revegetated could deplete the atmospheric load to a significant extent. However, such actions need to be enhanced through technology, economic and humanresource inputs. Reduction in wood/biomass use, from exclusive consideration of global warming, would not be desirable but a change from uses releasing CO_2 at rapid rates (*e.g.*, reckless fuelwood use) to those releasing CO_2 at slow rates (*e.g.*, timber, conversion of biomass to biogas through anaerobic digestion and using the gaseous end products to meet energy needs) would be useful (Houghton, 1990).

Measures to avoid any reduction in crop yields arising out of water-stress related situations under warmer temperatures need to be worked out. The options would include revival of traditional irrigation systems, introduction of appropriate technology of water harvest and use, shift in cropping patterns from less efficient crops such as paddy to more efficient ones like finger millet, in the mid- altitude zone.

A change in cropping systems from annual crops to perennial crops would reduce the atmospheric load of CO_2. There could be socio-economic constraints in increasing forest cover. Perennial cash crops, medicinal plants, wild trees producing edible oils, fruits could succeed in privately owned agricultural land through attractive public policies. This will increase the fraction of carbon in the biotic component with a concomitant decrease in atmospheric CO_2.

Uses involving combustion of biological material need to be checked from the point of reducing the emission rates of CO_2 from land to the atmosphere. Gradual replacement of fuelwood and fossil fuel as a source of energy, by hydroelectric power would be desirable (Saxena & Purohit, 1993).

With the predicted trends, photosynthetic rates will increase in the high altitude zones presently faced with cold stress. Soil amendments to increase the rates of nutrient release would be necessary to avoid large biomass build up in these areas.

Artificial planting/seeding would be required for increasing the CO_2 assimilation of these areas.

4. SUSTAINABLE RURAL DEVELOPMENT

4.1. The Concept

Sustainable development and effective management of natural resources and indeed rehabilitation of degraded ecosystems are all closely interlinked with one another. Ecological issues are tied up with social, economic, anthropological and cultural dimensions, since the guiding principles of sustainable development (Box 1) cut across these very disciplinary realms, with obvious trade-offs.

Box 1. The guiding principles of ecological sustainable resource management (adapted from Hare *et al.*, 1990)

- o Inter-generational equity: providing for today while retaining resources and options for tomorrow.
- o Conservation of cultural and biological diversity and ecological integrity
- o Constant natural capital and 'sustainable income'.
- o Anticipatory and precautionary policy approach to resource use, erring on the side of caution.
- o Resource use in a manner that contributes to equity and social justice while avoiding social disruptions.
- o Limits on natural resource use within the capacity of the environment to supply renewable resources and assimilate wastes.
- o Qualitative rather than quantitative development of human well-being.
- o Pricing of environmental values and natural resources to cover full environmental and social costs.
- o Global rather than regional or national perspective of environmental issues.
- o Efficiency of resource use by all societies.
- o Strong community participation in policy and practice in the process of transition to an ecologically sustainable society.

This implies that we have to make a series of compromises to achieve sustainable development in such a way that we do not lose track of the ultimate

objective, namely, rehabilitation and management of natural resources in a manner that satisfies current needs, at the same time allowing for a variety of options for the future. Though an ecosystem type (man-made ecosystems such as agriculture, a fish pond in a village or village itself visualized as an ecosystem; or natural ecosystems such as grassland, forest or river) may be the appropriate unit for convenient handling of the issues involved in sustainable management of natural resources, a cluster of interacting ecosystem types (a 'landscape') may be the most effective for a holistic treatment (Ramakrishnan *et al.*, 1994). A watershed is one such landscape unit. Further, from a sustainable developmental point of view, while one may bear in mind a long-term ideal objective to be achieved, ecological, social, economic or cultural constraints may necessitate designing short-term strategies, for enabling peoples' participation in the developmental process. To quote one example, while forest-based economic activities and cash-crop plantation programme may be the most appropriate as a long-term alternative to shifting agriculture in north-east India, there is no option except to have a redeveloped agroecosystem package for the region using traditional knowledge and technology as the starting point for a short-term strategy (Ramakrishnan, 1992a,b). Thus, sustainable development has spatial and temporal dimensions that need to be reconciled. Indicators of sustainable development are varied; therefore, here again, compromises are called for. Monitoring and evaluation has to be done using a number of diverse currencies (Ramakrishnan, 1993, Huntley *et al.*, 1991) that may be:

(a) ecological (land use changes, biomass quality and quantity, water quality and quantity, soil fertility, and energy efficiency),
(b) economic (monetary output/input analysis, capital savings or asset accumulation, and dependency ratio), social (quality of life with more easily measurable indicators such as health and hygiene, nutrition, food security, morbidity symptoms; the difficult to quantify measures such as societal empowerment, and the less tangible ones in the area of social and cultural values).

Further, institutional arrangements have to ensure peoples' participation, through a bottom-up approach for their organization, ensuring that each household takes part in the decision making process at the lowest level in the hierarchy, and with special dispensation for the weaker and vulnerable sections of the society. Village development Boards (VDB) of Nagaland is a case relevant to this discussion (Anonymous, 1980b). Local level institutional framework, should consider the following aspects:

(a) identification and strengthening of local level institutions that are already available such as those existing in the north-eastern region,
(b) the representative nature of these bodies and the extent to which individual family interests are taken care of,

(c) their role in decision making right from the project formulation stage through different levels of implementation,

(d) flexibility in function so as to take care of the interests of all sections of the society,

(e) education and human resource development that these institutions have been able to trigger, particularly for weaker and vulnerable sections of the society,

(f) ability of these institutions to stand on their own through empowerment in terms of capability building.

The case studies presented here elegantly exemplify these concerns.

4.2. Sustainable Mountain Development Framework

Mountains offer both opportunities and constraints for development (Fig. 7). Mountain societies are adapted to these constraints and opportunities through trial and error over generations. Development interventions involving technological and institutional changes attempt to increase the pace of development achieved otherwise

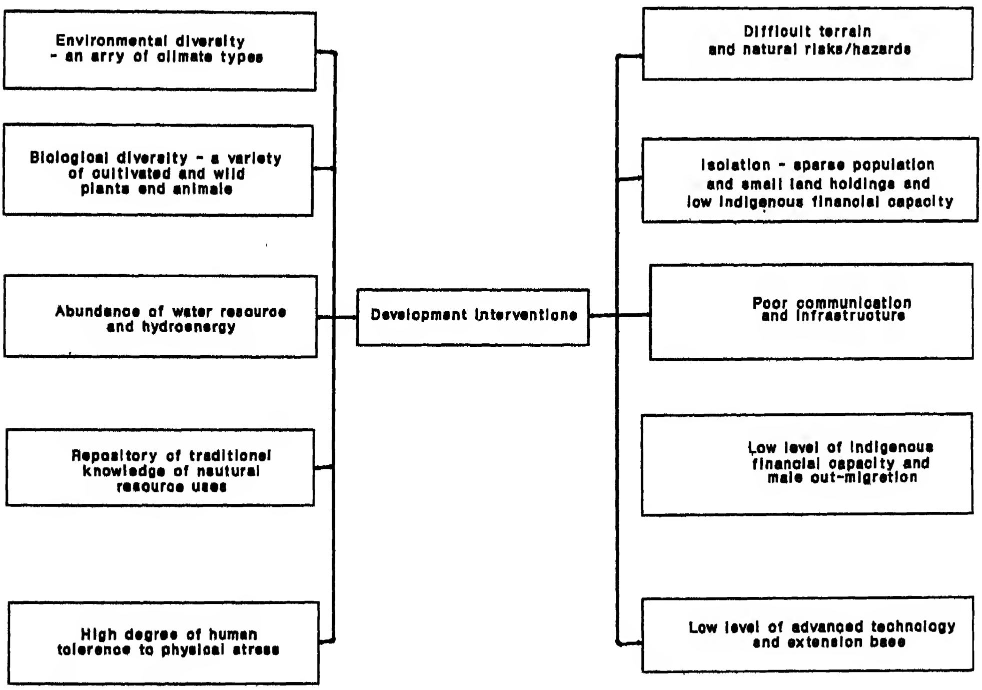

Fig. 7. Opportunities and constraints for development interventions in the Himalaya

through indigenous capacity. Conventional development approaches presumed negligible or even negative roles of local knowledge system. Local resource use practices and management systems were assumed to be inefficient in all respects simply because they have remain unchanged over long periods. Scientific investigations of local systems were undertaken long after conventional development approaches started penetrating the Himalayan region. Opportunities of development by capitalizing upon/reorienting the indigenous knowledge have received recognition in the conventional science and development planning only in recent years (Gilmour, 1989; Purohit, 1990; Ramakrishnan, 1992; Ramakrishnan *et al.,* 1993).

Development concerns in the Himalaya revolve around as to how could the resources of the region be managed for conserving/improving the environmental values of the region together with socio-economic development of mountain people. Linkages between ecological and socio-economic approaches ensures that development is made location specific. While conservation of natural resources figures as top priority on the agenda of environmentalists, possible ways of building upon the economic potential linked to infrastructural development, and advanced technology, and increased cash flow through a well developed market economy are the primary concerns of the deprived and desperate rural people. Sustainable management of natural resources is possible neither by asserting power by enforcing laws by the State in the name of wider public interest nor by giving free hand to the people to decide the balance between use of natural resources for the present and the future and/or for themselves and others. Reverting back to the historical time by entrusting management machinery in the hands of people, in the present circumstances, involves a risk of exploitation of natural resources for short-term gains. Though incompatibility between immediate local needs for economic development priorities and environmental conservation priorities for the region exists, there is scope for narrowing down this conflict. The objective of preservation/ conservation of the Himalayan environment can be achieved provided the actions adopted to serve the long-term interests of a wide group (people living in the Himalaya as well as those outside the region) is reconciled with immediate needs of the people of the region.

The difficult terrain, environmental hazards , poor communication and low level of scientific/technological progress has rendered marginalization of hill areas through conventional administered development. People of the region feel and think more about the disparity in the pace of development between the hills and the plains, between the urban and the rural areas within the mountains, the more and the less developed hill villages than about the scope of improving the quality of their life by themselves. The question of as to why the development advanced at a faster pace elsewhere has acquired greater importance than as to how the less developed people could become more developed. The issue of disparity on the one hand weakens the

indigenous potential to advance on development track and, on the other, magnifies the dependence of people on government for their development.

Isolation and natural impediments in mobility favored enormous diversity in socio-cultural systems adapted to local conditions and evolution of rich traditional knowledge on resource dynamics, uses and management. Hill societies in historical times have laid emphasis on self-reliance to secure their existence in isolated and inaccessible areas. The element of self-reliance is likely to be of more adaptive significance in more remote and inaccessible areas. An appropriate mix of self-reliance and dependence on external inputs is a prerequisite for accelerating the pace of development and for meeting the sustainability criteria. Bringing improvement in life quality of people with external inputs may be adopted on short-term considerations, but is not likely to be sustained on a long term basis. Developmental interventions must capitalise upon and add to the indigenous development capacities. Present levels of appropriate technological knowledge as well as capacity to put the existing knowledge in practice in the Himalaya need dramatic improvements from the point of the interests of the people settled in the region and many more settled in the adjoining low lands.

Regional development perspective of Himalaya seem to be clouded with environmental and economic issues; social issues being usually given a peripheral or secondary importance. Environmental degradation is more a problem of relationships among people competing for productive resources than of relationships between people and habitats (Horowitz, 1988). Development priorities for the mountains are justified for improving upon the life quality of mountain people themselves and also to persuade the people of the plains that the future of the mountains cannot be isolated from their own (Eckholm, 1975). However, to what extent a more marginal area like the Himalaya gets priority over a less marginal area like the Indo-Gangetic plains will continue to be a question that is resolved more by the political decision making process. Protection of interests of the indigenous population therefore must assume priority, and interventions should be aimed at sustainable development of the Himalayan region. Unfortunately, human dimension of environmental and developmental changes remain poorly understood (Fisher, 1990).

Development strategy is basically a set of actions identified by choices and compromises in the decision making process. The logical unifying principles of inducing sustainable rural development in the Himalaya would be:

* Realize the opportunities and constraints for development of mountain perspective
* Divert attention of people from 'what do they not have' to 'what they

have' for overcoming the present state of desperation
* Build up on the local knowledge, natural resources, skill and human capacities
* Make people realize the real costs of a given intervention by promoting their active participation in developmental activities
* Design people-Government participatory action frameworks clarifying responsibilities, accountability and profit/loss sharing.

Sustainability of any development intervention would depend upon a logical consideration of these opportunities and constraints. Huge variation in physical, biological and human systems in the region demand careful consideration of locational specificities while designing and implementing any development intervention. Further, since scientific knowledge base of the region is limited, efficacy of any intervention must be thoroughly tested before it is spread on a large scale.

4.2.1. Focus on Natural Resource Management

Production, consumption, preservation and distribution are the key processes characterizing resource dynamics and its reflection as social, environment and economic indicators of development (Fig. 8). In the conventional economic perspective, production is looked upon as a process operating at two levels - primary level - dealing with raw material available from biological (farms, forests and livestock) or non-biological systems (minerals) and - secondary level - dealing with value addition to raw material using labour, capital and technology inputs. Industrialization thus addresses production process at the secondary level. There are many factors like communication, transportation and marketing commonly referred as infrastructural facilities which influence primary as well as secondary level production processes and these are considered together as tertiary sector of development in conventional economic approaches. Production was viewed merely as a means of securing livelihood by the mountain societies; obtaining monetary profits, the core of economic growth, from the production process is a recent concern. Surplus of primary produce such as food grains used to be appropriated as contingencies in the event of natural catastrophes or to secure commodities not available locally (*e.g.*, farmers settled in high altitudes exchanging surplus potatoes, amaranths and buckwheat with paddy from farmers in low altitudes). Mountain people valued need-based exchanges more than opportunities for monetary profits through cash driven market. Present marginal status of the Himalaya is thus partly due to lack of economic concerns in the traditional socio-cultural systems of mountain people and partly due to slow pace of industrialization because of physical constraints and preexisting low level of infrastructural facilities. Realizing monetary benefits from production processes by the local populace is a recent consciousness in response to growing markets for resources of the region together with emerging technologies of value

addition to locally produced raw material at distant places in the lowlands. A critical issue in the present scenario is the growing incompatibility of regional and local development priorities - local populace pressing for improvement in infrastructural facilities, industrial growth and cash crops in order to realize economic benefits and regional imperatives for avoiding the risks of environmental degradation and regenerating the environment degraded in the past (particularly reforestation/ afforestation activities). Government set up does realize the local priorities but also carries the responsibility of implementing actions escaping regional or global criticism.

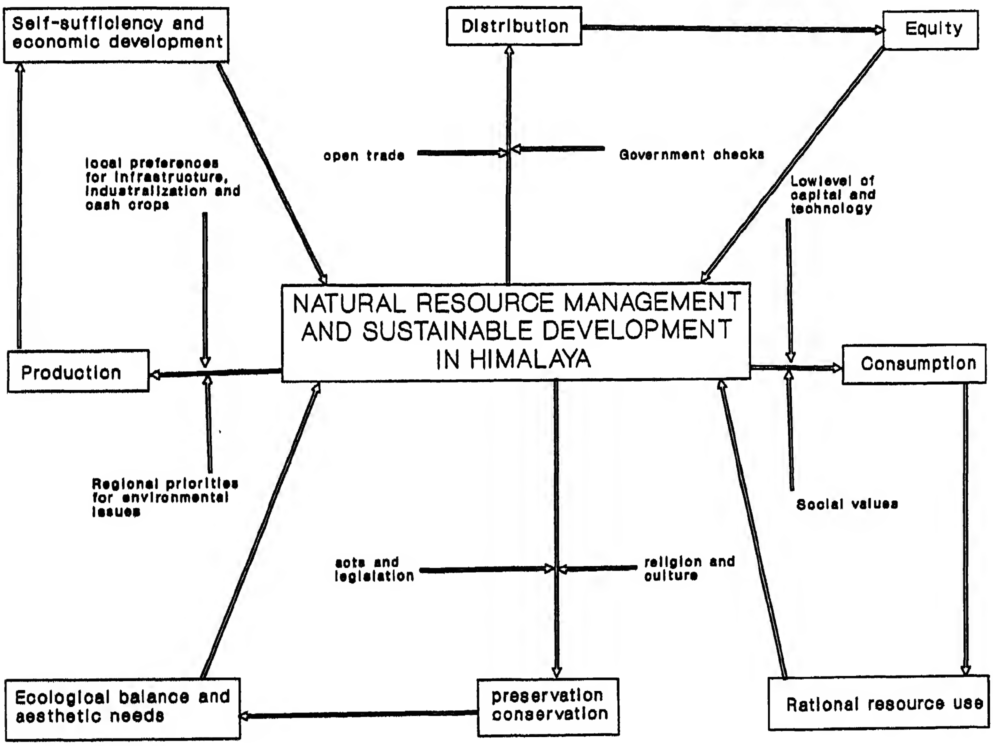

Fig. 8. Goals and determinants of sustainable development

Preservation/conservation of natural resources deserves importance because of fragility of the Himalayan environment and considerable damages, whatever be the causal factors, to the Himalayan landscape in the past. Values for conservation/ preservation of resources are deeply embedded in the religion and culture of the traditional societies. With advancement of administered development, the State came forward with legislative/administrative mechanism ensuring environmental preservation/conservation. However, the governmental mechanism of environmental conservation/preservation of the Himalayan environment also provided checks

and restrictions on age old traditional usufruct rights infusing an element of alienation toward governmental policies among the local populace. Issues related to the use of natural resources were delinked from the issue of proprietary rights or land ownership rights in the hills in historical times. Agricultural land was the only land-use where land ownership rights and use rights of individuals were recognized. Under difficult Himalayan terrain restricting mobility, mountain societies evolved as small cohesive set-ups where decision making process operated locally. Centers of decision making got gradually distanced from the mountains and mountain people started getting ruled by those who were far away from the realities. Decision making process started getting influenced more by values of the Himalayan resources as perceived by aliens than by the local population. Focus of State intervention shifted from resource use rights to resource/land ownership rights. State interventions thus proved counter-productive to the preexisting socio-cultural values for conservation. Rejuvenation of the age old cultural values together with reorientation of State interventions therefore deserves attention in designing and implementing approaches for the goals of environmental development of the area.

Consumption and distribution of the produce are the processes addressing social goal of development - the equity. Because of physical stress, isolation, environmental uncertainties, marginal cultural values of monetary profits, rationality in resource use evolved over ages among the indigenous societies. Consumerism could not proliferate partly because value addition technologies could advance and partly because exchanges pertained only to minimum needs for securing livelihood in the region. Low levels of advanced technologies and capital forced mountain societies to emphasize on primary level production processes (such as agriculture) or to move to centers of industrial growth located in low lands (male out migration). This also facilitated increasing unequal terms for trading raw material from mountains to the lowlands. With increasing exposure, local population started realizing the role of the exploitative market and industrialization processes. State did institute checks on open trade of raw material for protecting the interests of the marginal area. However, these checks at times and places proved non-existent. Though drawbacks in governmental programmes and policies are not ruled out, there are also serious drawbacks in the people's perception. People's demands are guided by their aspirations and not by the realities of constraints Government is faced with. People - Government partnership rather than conflicts could only mitigate the multitude of problems.

4.2.2. Reconciling Conflicts through Integration

A shift in emphasis from addressing ecological and socio-economic problems separately, to an integrated cross-sectoral view of multiple and diverse problems is visible in the policy documents of the Government, particularly during

the past few years (Anonymous, 1992a & b). Yet, advocacy and willingness for integrated approaches paving way for sustainable development is yet to be accompanied by development, demonstration, and rep ication of effective integrated development strategies serving ecological, economic and social development imperatives together. Programmes translating the new paradigm have been instituted but were found in no way more effective than sector-focussed development programmes instituted in the past. The lacunae are apparent both in programme design and implementation. Himalayan watershed management project funded by the World Bank was conceived as a development programme with a focus on integration of five sectors *viz.*, forestry, agriculture, livestock, horticulture and minor/micro level irrigation (Fig. 9).

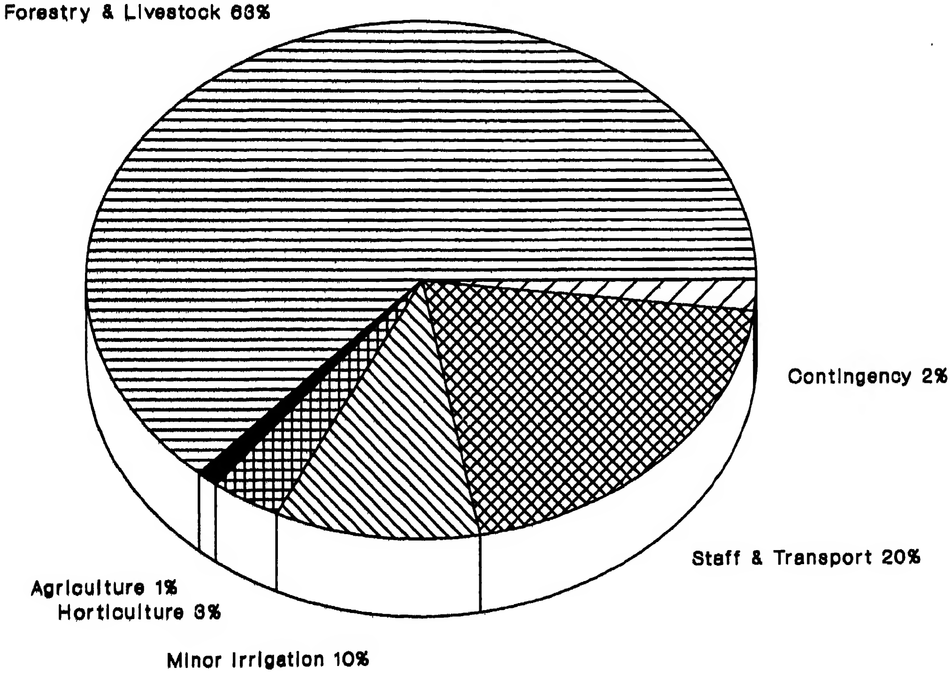

Fig. 9. Sector wise allocation of budget (expressed as percentage of total budget allocated to a given sector) in Himalayan Watershed Project (Target area 312,000 ha)

However diversion of as much as 63 % of financial investment on the forestry sector led peripheral importance to other sectors. Further, in the absence of a strong data base (even the basic data on rainfall, temperature and water yield are not available and there are methodological problems in extrapolating the data from a few stations to unsampled places), effectiveness of the management interventions envisaged was not achieved. Emphasis was on introduction of interventions new to

the people (chemical fertilizers, check dams, lined canals, storage tanks) by way of providing subsidy. Such interventions do become visible but are not likely to persist after the project support is withdrawn/terminated. Marginal importance placed on people's participation invokes a feeling in the local populace that interventions are more to serve national/global interests (*e.g.*, increasing the tree cover) than the local ones (*e.g.*, socio-economic development). People's participation would not only bring down the programme cost (22 % of project cost was incurred towards project staff and infrastructure) but would also remove many misconceptions and conflicts pertaining to people - Government relationships. Interventions supplementary/ complementary to the indigenous resource use practices and capable of improving upon the efficiency of indigenous systems are likely to succeed more than altogether new interventions in risk-prone mountain environments. Advancement in science and technology together with restructuring of institutional mechanisms of implementation of development activities is needed for enhancing the element of sustainability in the Himalayan scenario. Multiple facets of problems and potentials in the Himalaya demand integrated approaches. However, integrated approaches have yet to advance from merely bringing different development sectors under a common programme as at present, to a framework where interventions improving the state of one sector complement to the development objectives of the other sectors.

5. RECONCILING ECOLOGICAL CONCERNS WITH FOREST MANAGEMENT FOR TRIBAL DEVELOPMENT

5.1. The Scenario

Traditional tribal societies of India are largely confined to upland ecosystems. They are widely distributed throughout the sub-continent but with large concentrations along the Ghat forests of the peninsular India, the upland forests of central India, the Himalaya and its north-eastern extension ranges. They also occur elsewhere in the country, *e.g.*, tribal belts in Bihar, Bengal, Andaman and Nicobar islands, *etc.* It is worth noting here that what we call here as traditional upland societies are all not necessarily tribal by definition, because the term 'tribal' in the Indian context has a political connotation, being recognized as distinct groups to be protected through statutory provisions in the Constitution. Thus, the Kumaonis, Garhwalis, and others in the Himalayan zone are equally traditional in their social, economic and cultural sphere, as the tribals themselves. In any case, it is interesting that we do see a close overlap between natural resource concentrations and distribution of traditional societies, in that all of our remaining good forested areas are inter-linked with them. Indeed, even our mineral resources and water resources largely occur in areas where traditional societies live. It is for this reason that we seem to be in constant conflict, though avoidable, while reconciling our national developmental priorities with local developmental needs. Agriculture, forestry and

fishery are three major economic activities in the rural Asian tropics. Though we in India have made remarkable progress in terms of self-sufficiency in food through 'green revolution', a large section of our rural population still remain marginalized. The worst affected are the traditional societies including the 'tribals'. No doubt, India has its constitutional safeguards for protection of tribal interests. Yet, unwittingly, the tribals have often been the victims of the consequences of the centralized developmental planning process. With land use based economic activities, these traditional farming societies have no value for high energy-input agricultural technology, partly arising out of ecologically inappropriate technology introductions, and partly because of limited access to external energy subsidies and the cost factor associated with it. Further, these upland communities have been adversely impacted by the activities of the industrial man, having over-exploited the natural resources in their territories in the name of national development. Their problems have been accentuated because of increasing population pressure and the consequent fragmentation of the land holdings, now impoverished by environmental degradation. Much of India's natural resources like forest biomass, water and mineral resources being largely confined to these upland areas where traditional societies live, non-sustainable exploitation of these resources for industrial purposes by the people in the plains have impacted the upland societies through environmental degradation and human displacement leading to social disruption and misery. It is in this context that we looked at the whole question of sustainable development of the tribal communities of the north-eastern hill region by building upon traditional technology as the starting point (Ramakrishnan, 1992a), keeping in mind:

(a) local needs for sustainable livelihood of rural tribal communities,
(b) local and regional demand for natural resources for industrial needs, and
(c) regional and global concerns related to biodiversity and biomass burning.

5.2. The Tribal Problem

Over 400 tribal communities are distributed throughout the country, occurring in all States and Union Territories (Table 8), and they form about 8 per cent of India's total population (Anonymous, 1981). However, it should be noted that not all tribal groups are recognized by the government for special treatment and benefits, and those that are, belong to the 'scheduled tribe' category, under the Indian Constitution. Indeed, many traditional societies inhabiting upland areas (*e.g.* the traditional Himalayan societies) may not be tribal in their characteristics and yet they may form ecologically distinct groups, sharing similar developmental problems with tribals elsewhere. Therefore, social groups that could be considered traditional are many more than recognized.

Table 8. Distribution of Tribal Population in India

States/Union Territories	Total Tribal Population	Percentage of Tribal Population as of the total	Territories of tribal population as of the State
Andhra Pradesh	3,176,001	6.15	5.93
Bihar	5,810,867	11.26	8.32
Gujarat	4,848,586	9.39	14.22
Haryana	-	-	-
Himachal Pradesh	197,263	0.38	4.61
Jammu & Kashmir	-	-	-
Karnataka	1,825,203	3.53	4.91
Kerala	261,475	0.50	1.03
Madhya Pradesh	11,987,031	23.22	22.97
Maharashtra	5,772,038	11.18	9.19
Manipur	387,977	0.75	27.30
Meghalaya	1,076,345	2.08	80.58
Nagaland	650,885	1.26	83.99
Orissa	5,915,067	11.45	22.43
Punjab	-	-	-
Rajasthan	4,183,124	8.10	12.21
Sikkim	73,623	0.14	23.27
Tamilnadu	520,226	1.01	1.07
Tripura	583,920	1.13	28.44
Uttar Pradesh	232,705	0.45	0.21
West Bengal	3,070,672	5.95	5.36
Andaman & Nicobar	22,361	0.04	11.85
Arunachal Pradesh	441,167	0.85	69.82
Chandigarh	-	-	-
Dadra & Nagar haveli	81,714	0.16	78.82
Delhi			
Goa, Daman & Diu	10,721	0.02	0.99
Lakshadweep	37,760	0.07	93.82
Mizoram	461,907	0.89	93.55
Pondicherry	-	-	-
India	51,628,638	100	7.76

Source: Anonymous (1981)

A number of development programmes have been taken up during the last few decades in order to improve the socio-economic conditions of the tribals and other weaker sections of the society. These programmes suffer from many deficiencies. Highly heterogeneous tribal groups, each with distinct ecological, social and economic characteristics are often treated as a single homogeneous whole, right across a region where they may be located. This has resulted in the funds for development often being allocated without due consideration for the felt-needs of individual tribal groups. Even within the same tribe, access to the benefits was often restricted to limited sections of the society. Consequently, (a) some tribes are more advanced than others, and (b) economic stratification within the tribe often is very pronounced, leading to the emergence of an elite class within. From a marginalized primitive existence of the pre-independence period, the tribals now have become acutely conscious of their rights and privileges, largely due to the protection afforded to them through constitutional safeguards. Inspite of the deficiencies associated with developmental planning, the smaller impacts made through conventional development has raised the expectation of the tribal people. It is therefore most appropriate to look at a new paradigm for sustainable development and management of natural resources in the areas where the tribals live. This section attempts to do this using the north-east Indian case study (Ramakrishnan, 1992a), this region being one of the concentration points of tribals in the country.

5.3. Shifting Agriculture and Sustainable Development

In the north-eastern hill region of India, live more than 100 tribes with their own language and cultural characteristics, but with shifting agriculture (locally called Jhum) as a major land use. Other land use systems available in the region are valley land wet rice cultivation and home gardens (Box 2). Each one of these land use systems show large variations in cropping patterns, economic yield and ecological efficiencies, depending upon ecological and social settings. During the last 20-30 years, the shifting agricultural cycle (the length of the fallow period between two successive croppings on the same site) has drastically come down from a more favourable 20 years or more to about 5 years or even less. This is partly because of large-scale timber extraction from the region leading to invasion of the landscape by exotic and native weeds, resulting in replacement of forest by an arrested succession of weeds or large-scale desertification resulting in totally balded landscape. Increasing population pressure on the land has also contributed to the shortened shifting agriculture cycle. A shortened 5-year cycle obviously is not tenable because it exacerbates environmental problems in a variety of ways, apart from low crop productivity and social disruptions (Box 2). Governmental agencies, over the past 50 years or more, have tried in vain to replace shifting agriculture by sedentary terrace farming, which demands high energy inputs in the form of fertilizers, weedicides and pesticides. As the soil cover is thin and infertile and the

Box 2. Shifting agriculture (Jhum) in north-eastern India and social disruption (from Ramakrishnan, 1992a).

North-eastern India has over 100 different tribals, linguistically and culturally distinct from one another; the tribes often change over very short distances, a few kilometers in some cases. Shifting agriculture or jhum as the tribals call it, is the major economic activity. This highly organized agroecosystem was based on empirical knowledge accumulated through centuries and was in harmony with the environment as long as the jhum cycle (the fallow length intervening between two successive croppings) was long enough to allow the forest and the soil fertility lost during the cropping phase to recover.

Supplementing the jhum system is the valley system of wet rice cultivation and home gardens. The valley system is sustainable on a regular basis year after year because the wash-out from the hill slopes provides the needed soil fertility for rice cropping without any external inputs. Home gardens extensively found in the region have economically valuable trees, shrubs, herbs and vines and form a compact multi-storied system of fruit crops, vegetables, medicinal plants and many cash crops; the system in its structure and function imitate a natural forest ecosystem. The number of species in a small area of less than a hectare may be 30 or 40; it therefore represents a highly intensive system of farming in harmony with the environment.

Linked to this land-use are the animal husbandry systems centered traditionally around pigs and poultry. The advantage here is primarily that they are detritus-based or based on the recycling of food from the agroecosystem unfit for human consumption.

Increased human population pressure and decline in land area resulting from extensive deforestation for timber for use for industrial man and jhum has brought down the jhum cycle to 4- 5 year or less. Where population densities are high, as around urban centres, burning of slash is dispensed with, leading to rotational/ sedentary systems of agriculture. These are often below subsistence level, though the attempt is to maximize output under rapidly depleting soil fertility. Inappropriate animal husbandry practices introduced into the area, such as goat or cattle husbandry, could lead to rapid site deterioration through indiscriminate grazing/browsing and fodder removal, as has happened elsewhere in the Himalaya. The serious social disruption caused demands an integrated approach for managing the forest - human interface.

Box 3. Shifting agriculture (jhum) and sustainable development for north-eastern India (from Ramakrishnan, 1992b).

For improving the system of land use and resource management in north-eastern India, the following strategies suggested by Ramakrishnan and his coworkers are based on a multidisciplinary analysis. Many of these proposals have already been put into practice.

- o With wide variations in cropping and yield patterns under jhum practised by over a hundred tribes under diverse ecological situations, where transfer of technology from one tribe/area to another alone could improve the jhum, valleyland and home garden ecosystems. Thus, for example, emphasis on potato at higher elevations compared to rice at lower elevations has led to a manifold increase in economic yield despite low fertility of the more acidic soils at higher elevations.
- o Maintain a jhum cycle of minimum 10 years, (this cycle length was found critical for sustainability when jhum was evaluated using money, energy, soil fertility, biomass productivity, biodiversity, and water quality, as currencies) by greater emphasis on other land use systems such as the traditional valley cultivation or home gardens.
- o Where Jhum cycle length cannot be increased beyond the five year period that is prevalent in the region, redesign and strengthen this agroforestry system incorporating ecological insights on tree architecture (*e.g.* the canopy form of tree should be compatible with crop species at ground level so as to permit sufficient light penetration and provide fast recycling of nutrients through fast leaf turnover rates).
- o Improve the nitrogen economy of jhum at the cropping and fallow phases by introduction of nitrogen-fixing legumes and non-legumes. A species such as the Nepalese alder (*Alnus nepalensis*) is readily taken in because it is based on the principle of adaptation of traditional knowledge to meet modern needs. Another such example is the lesser known food crop legume *Flemingia vestita*.
- o Some of the important bamboo species, highly valued by the tribals, can concentrate and conserve important nutrient elements such as N, P and K. They could also be used as windbreaks to check wind-blow loss of ash and nutrient losses in water.
- o Condense the time-span of forest succession and accelerate restoration of degraded lands based on an understanding of tree growth strategies and architecture, by adjusting the species mix in time and space.
- o Improve animal husbandry through improved breeds of swine and poultry.
- o Redevelop village ecosystems through the introduction of appropriate technology to relieve drudgery and improve energy efficiency (cooking stoves, agricultural implements, biogas generation, small hydroelectric projects, *etc.*). Promote crafts and products based on leather, bamboo and other woods.
- o Strengthen conservation measures based upon the traditional knowledge and value system which the tribal communities could identify, e.g., redevelopment of traditional agroecosystems to conserve agroecosystem biodiversity, the revival of the sacred grove concept based on cultural tradition which enabled each village to have a protected forest once upon a time although few are now left.

nutrient losses from the system are very heavy, more and more fertilizer is often required to sustain the system over a time period, but with very low efficiencies. As weed problem gets exaggerated under sedentary farming, weed control assumes alarming proportion. For these ecological reasons and for a variety of social and cultural reasons related to land tenure and cultural and religious practices centred around shifting agriculture, the farmer often rejected the alternates to shifting agriculture as a permanent solution to the problem. Meanwhile the highly distorted shifting agriculture now being practised under short cycles of 5 years or so has become less and less tenable in the region. It is in this context that we stepped into the region to look at the whole issue of sustainable development, with people's participation. On the basis of extensive studies on agroecosystem and forest ecosystem function under a variety of situations and human ecology based analysis of village ecosystem function, short-term and long-term possibilities for sustainable development were recognized. A holistic approach for sustainable development that would link up agriculture, animal husbandry, and domestic sub-systems of the village ecosystem in the overall context of forest ecosystem function and management was identified (Box 3). The short-term (5-10 year) strategy considered transfer of technology from one tribe to another, as one of the pathways. Strengthening agroforestry component of the shifting agriculture system using locally identified and acceptable species such as the Nepalese alder (*Alnus nepalensis*) and improvement of valley land agriculture and home gardens with appropriately identified scientific inputs (linking traditional with modern technology) was considered as part of the short-term strategy. It is interesting to note here that the Nepalese alder technology is being promoted through the Village Development Boards of Nagaland (Gokhale *et al.*, 1985). On the other hand, a shift towards plantation economy based upon the home garden concept and organization of families on a cooperative production/marketing system alongwith forestry based activities was considered to be a possible long-term (50-100 year) objective for sustainable development of the region. The whole approach was to build upon traditional technology and knowledge base through modern scientific inputs, based upon a value system with which the people can identify themselves and therefore participate effectively in the developmental process.

5.4. Biodiversity Concerns in Agriculture

Biodiversity concerns in agriculture and sustainable agroecosystem development are linked with each other in a variety of ways. Yet, while talking about agriculture, one often visualizes a monotonous monocropping system totally devoid of biodiversity. This perception is largely due to energy intensive modern agriculture that we often see all around us. However, there exist in the tropics a wide range of complex agroecosystem types (as in the north-eastern region) with biodiversity comparable to that of the natural ecosystems and indeed occasionally exceeding it.

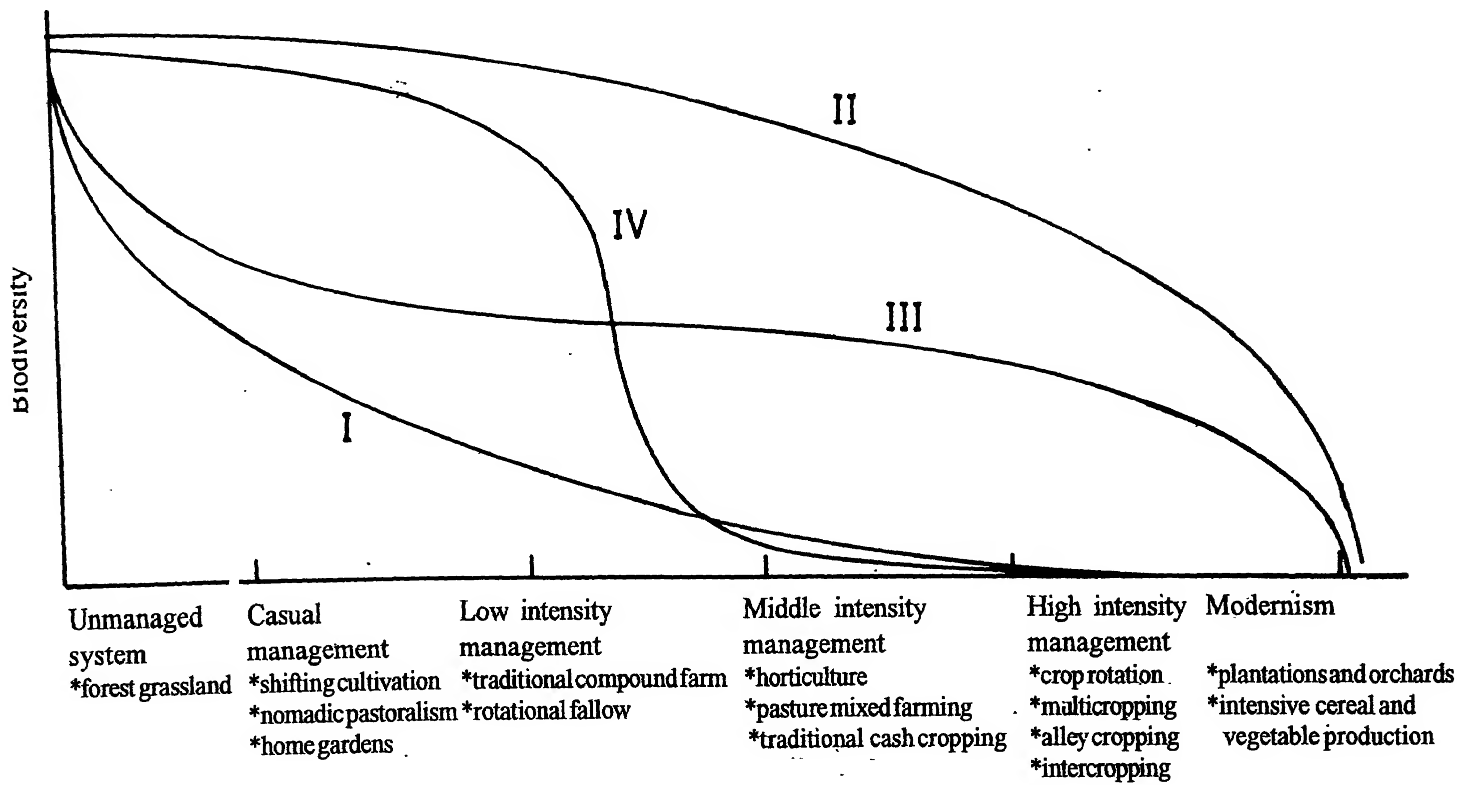

Fig. 10. Biodiversity changes (four patterns) as related to agroecosystem types and intensity of management. Curves I and II represent two extreme possiblities that seem to be unlikely. Curve III is a softer version of the ecologists' expectations, whilst Curve IV seems to be more likely and is the most interesting from the point of view of biodiversity conservation (Swift *et al*., 1994)

This biodiversity contributes in a variety of ways towards agroecosystem function such as production, decomposition dynamics, nutrient cycling and thus towards stability and resilience. Specific examples of these agroecosystem types (Ramakrishnan, 1992a) with varied levels of management ranging from the casual to high intensity, eventually leading to modern monocropping systems are indicated in Figure 10 (Swift *et al.*, 1994). The traditional agroecosystem types available in the north-eastern India has most of the agroecosystem types ranging from casually managed through low intensity management to middle intensity management systems. The shifting agriculture, home garden, valley land wet rice cultivation, rotational fallow and the traditional horticulture and cash crop farming systems, with all the variant types to be found in each one of them contribute to rich crop biodiversity where a variety of species and cultivars are handled and conserved by the different tribes of the region. It is generally acknowledged that biodiversity decreases as habitats change from forest to traditional agriculture, and then on to modern agriculture. While a variety of models for loss in biodiversity under varied intensities of management regimes for agriculture are proposed (Fig. 10), it seems obvious that biodiversity decline is sharp somewhere in the area close to the middle intensity of management (Curve IV). If that be so, it is crucial to have a level of management that is closer to this critical area for sustaining biodiversity in agriculture (Swift *et al.*, 1994). The sustainable development of agriculture suggested for the north-east India being in the middle intensity management range, this approach takes into account biodiversity concerns. There could be three different pathways for sustainable agriculture:

(a) evolution by incremental change,
(b) restoration through the contour pathway, and
(c) development through the auto-route (Box 4) (Swift *et al.*, 1994).

Realizing that biodiversity does contribute in a variety of ways to ecosystem functions (Ramakrishnan, 1992a) and that agroecosystems do harbour a great deal of biodiversity valuable for human welfare, it is reasonable that we go in for a mosaic of natural ecosystems coexisting with a wide variety of agroecosystem models derived through all the three pathways. Such a highly diversified landscape unit is likely to have a wide range of ecological niches conducive to enhancing biodiversity and at the same time ensure sustainability of the managed landscape. Arising out of this discussion, and relating this to the north-east Indian context, it seems that for the tribals in the region, following an incremental pathway seems to be the most obvious choice, at least as a short-term strategy for sustainable development. While the auto-route seems to be of limited value being restricted to wetland rice cultivation in the valleys, in view of the fragile mountain soil conditions elsewhere in the hill slopes, the contour pathway offers possibilities for sustainable agriculture, at least as a long term strategy, provided peoples' participation is ensured right through

Box 4. Pathways of agricultural development (after Swift *et al.*, 1994)

The 'auto-route' to maximal productivity:

Modern agriculture as a production system is based upon heavy external energy subsidies and in that sense is different from natural ecosystems that are regulated by internal controls. An appropriate metaphor would be the engineer who plans an autoroute by drawing a straight line from place to place on a map and proceeds to build a straight and level road regardless of the physical impediments. Such an agroecosystem type would stand apart as an artificial entity from the rest of the landscape - an attempt to convert the natural ecosystem into one that contains only those biological and chemical elements that the planner desires, almost irrespective of the background ecological conditions. *e.g.*, the 'Green Revolution' model.

Restoration - the 'contour pathway' to sustainability:

The 'contour pathway' seeks to acknowledge and work with the ecological forces that provide the base on which the system must be built, while acknowledging the social, economic and cultural requirements of the farming communities. Working with nature, rather than dominating it, this approach would involve active planning with the nature of the background ecosystem fully in mind. *e.g.*, the Sloping Agricultural Land Technology (SALT) developed in Philippines is one such system that approaches closer to this approach, though the initial reaction to the extension of SALT has not been very encouraging for reasons related to: (a) land tenure difficulties and (b) heavy labour investment. Many agroecosystem types in the 'low' and 'middle' intensity management categories (*cf.* Fig. 10) will come under this pathway.

Evolution by 'incremental change':

Many traditional agricultural systems need to be redeveloped through incremental, rather than quantum change, anything drastic may not find acceptance by the local communities. In this incremental change towards sustainable development, one may have to consider a short-term strategy that may be constrained because of ecological, economic, social or cultural reasons, apart from a more ideal and perhaps desirable long-term strategy. The possible ways in which a forest farmer practising shifting agriculture and other land uses such as valley wet rice cultivation or home gardens could pick up an appropriate variant from the local types that may be available or incremental change that could be brought about by strengthening the agroforestry component of the distorted shifting agriculture under a short cycle of 5 years or less through introduction of the Nepalese alder (*Alnus nepalensis*) are illustrative of this pathway for sustainable development.

Landscape mosaic:

Compared with a landscape model that is often seen now, where pristine unmanaged ecosystems are set in a sea of intensive large-scale agroecosystems, it may be desirable to have a mosaic of agroecosystem types derived through all the three pathways coexisting with natural ecosystem types, managed or unmanaged. Maintenance of the overall sustainability of the system requires the patchwork mosaic that would, albeit inadvertently, be the best plan for biodiversity conservation in general.

the planning phase.

5.5. Concerns Relevant to Forest Management

5.5.1. Holistic Approach for Sustainable Forestry

In the north-eastern Indian context, agriculture and forestry are closely inter-linked with one another. Indeed, the entire village ecosystem functional attributes need to be considered, if one were to design effective forest management strategies for the hill areas. With rapid decline in forest resources, partly due to timber extraction and partly due to shifting agriculture, stabilizing this land use is critical for sustainable forestry in the region. The strategy for agriculture redevelopment should be based on strengthening the agroforestry component for building up soil fertility, which otherwise is build-up through natural processes of forest succession where trees play a key role. Such a strategy would also take the pressure off from forests. The modern agriculture technology, through external subsidies of fertilizer, has often not been able to effectively replace the traditional way of recovering soil fertility through forest regrowth under shifting agriculture in the humid tropics. Social constraints such as land tenure pattern that is based on community ownership, and the present level in economic development of the society do not permit drastic departures form the traditional land use practices. Therefore, sustainable development has to consider a short-term strategy based on traditional technology that would avoid social disruptions. A more ideal long-term strategy, appropriately designed should be based on a gradual shift in land use pattern through community participation. Thus, a shift to cash crop plantation economy could be a long-term strategy in the north-east Indian context, but by basing it on the concept of home gardens, and organizing the whole economy on a cooperative basis. This would permit exploiting to the maximum, the integrity of the family as a unit for development (tribals could be fiercely independent) and yet capitalising upon the cooperative spirit of the tribals (even in the jhum operations, all labour-intensive activities are done on a cooperative basis).

5.5.2. Rehabilitation of Degraded Lands and Forest Biodiversity Conservation

The concept of architectural attributes of shrubs and trees is useful (Ramakrishnan, 1986, Ramakrishnan *et al.*, 1982), when these components are to be brought in during forest ecosystem restoration (Ramakrishnan, 1992a, b). Our studies show that early successional light demanding species have the following attributes:

(a) faster extension growth for the leader axis,
(b) faster branch production,

(c) greater allocation of resources for shoot growth compared to root growth,
(d) more allocation of biomass to the first-order branches,
(e) greater plasticity in branch orientation,
(f) a large leaf population that is loosely organized on the skeletal framework of the tree, and
(g) a large population of younger leaves on the tree at a given time.

Late successionals, on the other hand, have contrasting attributes, where natural selection has been for shade tolerance. If the root architectural changes are considered over a successional gradient, a few contrasting features between early and late successional species become obvious. The early successionals allocate more biomass to the shoot system compared to the root system so that they have a high shoot/root ratio; in contrast, late successionals have a low ratio. Further, early successionals have more root biomass located in the surface layers of the soil, whereas the late successionals have root that are more uniformly distributed into deeper layers; the mid-successional species fall in between. All these contrasting features of early versus late successionals are geared to permit early successional species to capitalize upon a high light regime of an open early successional environment making effective use of nutrient enriched surface soil layers (exploitative strategy). On the contrary, the late successional species have a 'conservative strategy' to make adequate growth in an environment where resource availability is limited. Mixed plantations, having many distinct ecological advantages over monoculture forestry, could also be economically productive or even better than the latter, if compatible species are used. Fast-growing, light-demanding early successional species could form compatible mixtures with shade-tolerant mid- or late-successional species for exploiting light availability at different canopy levels and thus optimizing production per unit area. Such a mixture would also allow optimum use of nutrients from the soil profile, the early successionals exploiting surface soil layers, and the late successionals reaching deeper down. It should even be possible to have a 'condensed succession' for revegetation of damaged sites by appropriate mixing of the different categories of species and by appropriately adjusting species introduction into the mixture. For social forestry programmes, to meet fodder, fuelwood and timber needs of the rural population, early successional native species would be appropriate because they have a fast growth rate with rapid turn-over of leaves, and therefore, resource mobilization and utilization are optimal. Social forestry systems developed as village wood lots along with agroforestry would take the pressure off the natural forests and contribute towards their conservation. In the rehabilitation of degraded lands of north-east India, keystone species such as Nepalese alder (*Alnus nepalensis*) and others are important. Bamboos which often have key nutrient conservation role for nitrogen, phosphorus and potassium also traditionally valued by the tribals of north-eastern India. Such

key species often trigger peoples' participation in forest management.

5.6. Linking Ecological and Social Processes

5.6.1. System Level Generalised Linkages

Shifting agriculture (jhum) in north-eastern India is a human problem, in that the system has fallen to disrepute because of the shortening of the jhum cycle (the length of the fallow period between two successive croppings on the same site), partly due to deforestation and the consequent land degradation and partly to increased population pressure. Yet, scientists and technologists have not yet come up with an effective technology that could build up and maintain soil fertility, as effectively as through natural processes of forest regeneration and forest succession through the fallow system, where the tree component plays a key role. Terracing suggested as an alternative has failed to catch on because it is based on high energy subsidies such as fertiliser. These inputs are costly and the fertiliser use efficiency of the system is very low in these thin mountain soils under the heavy rainfall situation that prevails in the region. Under these circumstances, we have suggested a variety of options for sustainable development of the region on both short-and long-term considerations, as discussed earlier (Ramakrishnan, 1992a). In order to do these, we had to look at the wide variations that exist in all the land use systems, variations based upon ecological, social and cultural differences. Other inter-linked components such as animal husbandry and domestic sub-systems of the village as an ecological system had also to be evaluated. In this holistic approach the linkages with forest ecosystem and its management had to be integrated.

Cultural dimensions are often important. The entire jhum calender year, starting from slashing and burning of the vegetation in December-January, burning of the slash in April, sowing of the crop species of the mixed cropping system with the onset of monsoon in May, sequential harvesting of crop species (the number of crop species may range between 8 to 35 or more depending upon the jhum cycle and the tribal community involved) starting from June and going up to December are all linked with a variety of cultural and religious events. Therefore, the short-term strategy for sustainable development of the tribal societies should keep in mind the finer details that are incorporated in the alternate to jhum. That is why, when the Nepalese alder technology was incorporated to strengthen the tree component of this agro-forestry system, it caught on with the local communities. They could organize their jhum system with a 5-year cycle, possibly resort to light burn once in 5 years, continue with mixed cropping procedures, harvest the tree coppices once in 5 years without removing the tree stump, and yet continue with all the cultural practices, since the departure made from the traditional jhum procedures is minimal. This is one of reasons why, this approach in designing a short-term strategy for an alternate

to jhum could find acceptance from the local people; this fits in with the value system which they cherish.

Even a long term strategy for sustainable development of the region need to consider traditional technology and value system. If a plantation economy based on economically valuable perennial species is a desirable long-term objective (for 50-100 years), then the home garden concept already available with the local people is one on which this whole system could be organized. This would then mean that plantation systems are developed as family enterprises and collection of the produce, marketing, and processing are all done on a cooperative basis. This would ensure that the land remains with the tribal societies and they are able to preserve their cultural values without being threatened from outside.

Even in the area of rainforest management in the region, we need to learn our lessons from the traditional practices that are strongly rooted in culture. Jhum as traditionally practised with a long cycle of 30 years or so result in only small-scale disturbances which ensure biodiversity in the forest ecosystem; the mixed cropping system ensures biodiversity in agriculture and therefore has desirable elements in it, which could be integrated with agroecosystem redevelopment.

Many tribal societies such as the Khasis and the Jaintias of Meghalaya maintain rigorously protected sacred groves. They believe that their Gods and spirits of the ancestors live in these protected forests and therefore any damage to them will bring bad luck. A variety of religious ceremonies are performed to propitiate the Gods and the spirits. Indeed, in many areas in the region where environmental degradation and desertification have set in on a large scale, these sacred groves serve as relic bench marks for the study of forest ecosystem function and for drawing lessons for forest management.We shall see more details of this interesting linkage between ecology and culture with implications for ecosystem management and sustainable development. In our subsequent discussions too in doing this generalised integration between ecological and social science paradigms, we have found the participatory mode of research to be the most effective.

5.6.2. Process Level Finer Linkages

While working with the mixed cropping system under jhum, a number of process level linkages could be recognized.

The chief reasons for the mixed cropping system are:

(a) the farmer wants to capitalize upon the rapidly declining soil fertility from the steep hill slopes of 30 to 40° and maximize production,

(b) he tries to obtain all his varied needs of cereals, legumes, tubers, vegetables and even fibre from the same site during one cropping season before he moves to another site, and

(c) the mixed cropping system is an insurance for crop failure, since even if one crop fails, there are many others to fall back upon. In organizing the mixed cropping system, the farmer depends upon the empirical knowledge he has developed on the basis of his vast experience. Thus when he has to work with a low fertility soil under a short jhum cycle of 5 years, the farmer emphasizes more on nutrient use efficient tuber crops rather than on cereals, in order to optimize production from the system. Even under any given cycle, the more nutrient use efficient crops are placed on the top of the slope and the less efficient ones are emphasized at the bottom of the slope, again based upon his intuitive experience.

Sequential harvesting of crops is an elegant way in which the farmer achieves synchrony between nutrient release and uptake. When a given crop matures, the biomass is put back into the plot after removal of the economically valuable component. The organic residue acts as mulch on the soil surface protecting the soil from erosive processes and the slowly released nutrients are taken up by the crop. This is an elegant example of organic residue management. Sequential harvesting also reduces interspecific competition. The harvested crop creates more space, increased light penetration to the ground level and reduces competition for nutrients when the next crop is at its peak growth.

Weed management is another area where ecological and social processes have closely evolved. The tribal farmer weeds his plot 2 to 3 times during the cropping season, though the weeds are under check under the dense canopy of the mixed cropping system. However, unlike the Nepali or Bihari farmer who have adopted the jhum system after they have got themselves integrated into the rural tribal set up, the tribal farmer himself leaves just about 20% weed biomass *in situ* without being pulled out. Many of the tribes that we have studied in the north-east consistently follow this practice. Indeed, even traditional societies in Mexico involved with the Maya system of agriculture are credited with this practice (Gliessman, 1988) - a case of parallel evolution of traditional technologies in regions geographically far apart. The interesting aspect of this technology is that the farmer's perception of the value of weeds in the system for soil and nutrient conservation, and his ability to perceive the weed as a 'non-weed', *i.e.*, he knows precisely when the weed stops interfering with his crop and yet has useful functions in the system, aspects that we have studied in detail, under the jhum system. It is equally interesting to find that the tribal farmer puts back the pulled out weed biomass back into the plot which acts as a mulch on the soil surface with all the useful functions that the mulch does. This again contrasts the way weeds are handled by the nontribal farmer

in the region, who because of his farming background puts away the pulled out weed biomass.

In many areas in the north-east India where local population pressures are more intense, as in the neighbourhood of Shillong township, the jhum cycle has come down to less than 5 years, leading in extreme cases to continuous cropping year after year through a rotational fallow system of agriculture. The fallow period could be 1 or 2 years, or it may even be just the fallow regrowth of a winter season. In his mixed cropping system, the farmer uses a number of lesser known plants of food value, of which *Flemingia vestita* (Gangwar & Ramakrishnan, 1989) is significant for this discussion. This species has been selected by the jhum farmer again based on his experience. The tuber, rich in protein, stored in gunny bags placed belowground serves as a food supplement during the lean season when traditional food supply is limited. Our studies suggest, through his mixed cropping system and by raising a pure crop of this species once in 3 to 4 years, the farmer is able to add as much as 250 kg of nitrogen per hectare per year. The farmer, on the basis of intuitive experience knows to adapt traditionally evolved technology to fit in with his present day requirements.

The Nepalese alder (*Alnus nepalensis*) is a tree traditionally conserved by the jhum farmer in his plot of land, while doing slashing and burning of the vegetation. Though we were able to come up with a number of species that could be used to strengthen the weakened tree component of this agroforestry system, only this species could find ready acceptance with the tribal farmer. Closer examination of this species showed that this species could fix up to about 120 kg of nitrogen per hectare per year under conditions of proper spacing and cultivation in the jhum system along with the crop species at the ground level. When this species was taken to the jhum farmer by the local Governmental agencies of Nagaland, it found ready acceptance by the farmer. Through the alder technology, the jhum could be redeveloped and a 5-year jhum cycle made sustainable for the region. This species which is a coppicing one could be harvested once in 5 years and the left-over tree stump could provide future harvests through regrowth. The traditional jhum farmer recognized the value of this species through his experience; he knew that this multipurpose species does good to his crops in some way and we know how this non-leguminous species fixes nitrogen in the soil through the root nodules. This suggests that we may have many viable technologies available for adoption by local communities, but only those that agree with the value system with which they can identify themselves will find acceptance at least in the short-term. After implementing the short-term strategy for sustainable development, one could work out a long-term plan for sustainable development.

Many species of bamboo (*Dendrocalamus hamiltoni, Bambusa tulda*, and *B. khasiana*) are shown by us to play a key role in conservation of nitrogen, phosphorus and potassium in the jhum fallows. These bamboo species are also traditionally valued by the local communities and often grown along the margin of their agricultural plots and as part of the home garden system; these species find a variety of traditional uses such as for home construction, making of household utensils, as tubing device for water transportation, as thatching material, *etc*. These species could appropriately be used as a fence around agricultural plots to protect and enrich the soil with nutrient input. These species could also play key role in nutrient conservation when restoring degraded lands, along with the Nepalese alder, discussed above.

While working in the sacred grove forests of Cherrapunji in Meghalaya, we came across four dominant tree species, namely, *Englehardtia spicata, Echinocarpus dasycarpus, Syzygium cuminii* and *Drimycarpus racemosus* that contain a high level of nitrogen, phosphorus and potassium in the leaf tissue, inspite of the fact that these species grow in highly infertile soils (Khiewtam & Ramakrishnan, 1993). These are keystone species in an ecological sense that perform key functions of nutrient conservation in this protected ecosystem. These relict forests are protected by local people for religious and cultural reasons. Similarly, the Nepalese alder and the bamboos are keystone species in an ecological sense because they perform key functions of nutrient conservation and enrichment in the ecosystem of which they form a part. These also are species that are traditionally conserved by local communities through a social process of selection. In other words, these ecologically significant keystone species are also socially selected keystone species, a close parallelism between ecological and social processes operating at the ecosystem level.

While linking ecological with social processes for the purpose of sustainable development with peoples' participation, one may end up with identifying one or two critical driving factors that would trigger the developmental process. To cite one such example, in the Himalayan region, water was identified as the key factor for land use development in the entire Himalayan belt, right from north-west to the north-east (see the following section). Water is a scarce commodity outside the monsoon season even in areas that may receive up to 24 meters of rainfall in an exceptional year, as at Cherrapunji. Leave alone water use for agricultural development, people often find it difficult to procure drinking water. Therefore it was not surprising when local communities consistently identified water as the key resource in short supply. By harvesting surface run-off water of the rainy season and by diverting sub-surface seepage water through cheap rainwater harvesting tanks (Kothyari *et al.*, 1991), we were able to link it with a variety of ecosystem rehabilitation efforts which elicited enthusiastic community participation.

Box 5. Assumptions concerned with rehabilitation of degraded sites in south and central Asia (after Ramakrishnan *et al.*, 1994)

Assumptions:

A.1. Rehabilitation ecology has to effectively integrate ecological, economic, social, cultural and political dimensions of the setting in which it is attempted. In this, ecological concepts and processes should tie up with social processes and perceptions.

A.2. In order to integrate these components, effective linkages between the people and their institutions, governmental agencies, non-governmental organizations, scientists and technologists are essential.

A.3. Since there are many interconnections between ecosystem types in a landscape, and since tinkering with one type may impact another, it becomes imperative to consider landscape as a networking unit for rehabilitation. The approaches for a given ecosystem type may differ, but within a given framework.

A.4. An understanding of the ownership and use patterns of natural resources (private, common, public or any combination of these three ownerships) are critical for strategies and will require different rehabilitation tactics.

A.5. Rehabilitation may have to operate under varied ecological/ economic/ social/ legal/ political/ cultural constraints. Further, the objectives of rehabilitation may differ. Therefore, one may have to consider different time frames: short (up to 10 years) or long term (up to 100 years) strategies.

A.6. Whilst rehabilitation work should provide a wide range of benefits to stake holders, the socio-economic needs of the local communities and user groups should be a major consideration.

A.7. Ecological and socio-cultural concerns should determine technological interventions in order to ensure that the outcome agrees with local perceptions and value system.

A.8. Appropriate policy decisions are important for effective implementation of rehabilitation programme, while doing so such decisions should take into consideration all the ramifications (ecological, social, cultural and economic) that may act as an incentive/disincentive for rehabilitation.

A.9. Soil and water conservation and management is crucial for ecosystem rehabilitation.

A.10. Understanding the history and the causes for the present status of ecosystem degradation is crucial for designing strategies for rehabilitation and management.

A.11. Ecosystem rehabilitation and management is a dynamic process and therefore should be monitored continuously, and should be flexible and responsive to modifications.

A.12. Ecosystem rehabilitation and management is site specific.

Box 6. General hypotheses concerned with rehabilitation of degraded sites in south and central Asia (after Ramakrishnan *et al.*, 1994)

General hypotheses

G.1. Rehabilitation and management would only succeed if short-term economic benefits are assured to local communities, apart from long-term benefits envisaged.

G.2. If rehabilitation and management strategies are to be effective and successful, womens' participation is necessary.

G.3. Without a broad understanding of the complexities of the system (through rapid appraisal methodology), rehabilitation strategies may not succeed.

G.4. Unless ecosystem rehabilitation and management leads to a general improvement and maintenance of soil fertility and water quality, it is not sustainable.

G.5. Ecosystem rehabilitation will be sustainable only if (a) internal control of processes (*e.g.* resource recycling) within the ecosystem are strengthened, (b) dependence on external subsidies (*e.g.*, fertilizers) are minimised, and (c) self-regenerating capacities enhanced, to the extent feasible.

G.6. In order to succeed, ecosystem rehabilitation should have strong community participation in planning, management, implementation, and continuous monitoring of all these parameters.

G.7. Unless rights and responsibilities of ownership are clearly defined and understood by all the participants, ecosystem rehabilitation is not likely to succeed.

G.8. If community participation is to be effective, community/user group institutions will have to be built into the rehabilitation strategy.

G.9. Unless land capability analysis and classification, taking into consideration scientific/traditional knowledge is integrated, rehabilitation work will not be effective and sustainable.

G.10. Empowerment (training, institutional, access to facilities and resources) of local communities in general and vulnerable sections (landless and women) in particular is crucial for the success of any rehabilitation programme.

G.11. In order that rehabilitation work is sustainable, surface and ground water resources and its exploitation is monitored and appropriately regulated through institutional mechanism.

Agroecosystem redevelopment in the Garhwal and the Kumaon hills, mixed plantation forestry and Ringal bamboo related forestry activities in the Kumaon hills, whole watershed development in the Sikkim region and redevelopment of shifting agriculture in the north-east are some of the activities which had a strong community participation. Because, the critical factor was provided, namely water outside the monsoon season, rehabilitation costs were minimised and with distinct economic benefits accruing to the local communities rather quickly.

5.7. Future Strategies

In the ultimate analysis, if sustainable development is to be effectively carried out, one has to take into consideration not only ecological, but also social, economic and cultural aspects. Indeed, the assumptions (Box 5) and hypotheses (Box 6) set here formed the basis for formulating another set of about 40 specific hypotheses (Ramakrishnan *et al.*, 1994) of value to scientists, non-governmental voluntary groups, governmental agencies and those involved in monitoring and evaluation.

6. Rehabilitation of Degraded Community Land - Designing a Model meeting Sustainable Development Goals and its Testing in High Altitude Villages

6.1. Delimitation of the Scope and Objectives - Degraded Village Lands as the Target Area and Villagers as Direct Beneficiaries

There are many and varied dimensions of sustainable development. Hierarchical analysis of regional to local sustainable development perspective revealed the possibilities of improvements in technological efficiency of preexisting traditional land based production systems, introduction of new production systems and their economic and social implications in the changing circumstances. Table 9 summarizes the options of interventions classified in three categories identified by legal status of the ownership of land *viz.*, privately owned farm lands, civil lands owned by the State but whose biological produce is available for use by the community and where private farming is legally prohibited, and forests managed by the people (Panchayat Forests) or by the Government Forest Department (Reserve Forests). Land ownership rights in individuals promote sustainable farm management by farmer's own efforts with whatever support is arranged by the Government. Forest Department and Forest Panchayat have been created for management of Government forests and village community forests (Panchayat Forests), respectively. Land lying within limits of a village other than those covered in these two categories have been neglected because of their ill defined legal ownership status and management responsibilities. It is evident that village lands other than privately owned farms and

Table 9. Feasible interventions for land redevelopment in selected villages

Category of land by ownership rights/ and redevelopment options	Opportunities/constraints Institutional	Technological	Environmental	Benefits/costs Economic	Social	Environmental
A. On privately owned agricultural land						
Increasing the cropping intensity	No constraint	Limited technological knowledge on high altitude slopeland agriculture	Low temperature constraints	Monetary benefits to individual farmers	Less likelihood of social benefits like equity and more likelihood of within village inequality	Risks of soil erosion and depletion of soil fertility
Promoting cultivation of high value food crops	Weak arrangements for marketing	Rich traditional knowledge	Climatic advantages	Monetary benefits to individual farmers	Less likelihood of social benefits like equity and more likelihood of within village inequality and more dependence on market for meeting food demands	Risks of soil erosion and depletion of soil fertility
Promoting cultivation of medicinal and aromatic plants	Weak institional arrangements for marketing	Traditional knowledge on environmental relationships, distribution and uses, and existing scientific knowledge of cultivation of quite a few species	Climatic advantages	Monetary benefits to individual farmers	Less likelihood of social benefits like equity and more likelihood of within village inequality and more dependence on market for meeting food demands	Protection of natural vegetation
Promoting realisation of monetary profits through improved marketing	Weak institional arrangements for marketing	Nil	Climatic advantages	Monetary benefits to individual farmers	Less likelihood of social benefits like equity and more likelihood of within village inequality	Sustainable agriculture
Promoting on farm tree planting	Lack of institutional mechanisms securing compensation in the events of reduced crop yields	Considerable technological knowledge on tree culture exists	Abundance of a variety of potential tree species	Negligible	On farm production of fuelwood and fodder, allevation of stress on women	Conservation
B. On civil lands owned by the State available for community development and not for private farming						
Promoting improvement in tree cover through afforestation /reforestation	Lack of priorities for such activities in development programmes sponsored by government and lack of former's interest in improving the land not owned by them	Adequate technological knowledge but lack of planting material of species preferred by the villagers; difficulties of access to government agencies	Environmental regeneration in degraded lands	Benefits through in the long run (>20 years) likely from forest produce	Mobilization of community efforts and thereby social benefits in terms of cohesion of village community	Environmental regeneration/conservation and reduction in pressure on existing forests
Cultivation of temperate bamboos	Lack of priorities for such activities in development programmes sponsored by government and lack of former's interest in improving the land not owned by them	Adequate technological knowledge but lack of planting material of species preferred by the villagers; difficulties of access to government agencies	Environmental regeneration in degraded lands	Harvestable material within 4-5 years, monetary benefits through cottage industries, increased levels of palatable grass production	Mobilization of community efforts and thereby social benefits in terms of cohesion of village community and benefits of ringal to men and fodder to women	Environmental regeneration/conservation and reduction in pressure on existing forests
Cultivation of medicinal and aromatic plants	Lack of priorities for such activities in development programmes sponsored by government and lack of former's interest in improving the land not owned by them	Adequate technological knowledge but lack of planting material of species preferred by the villagers; difficulties of access to government agencies	Environmental regeneration in degraded lands	Returns start from3rd/ 4th year by sale of produce	Since protecting the site becomes a prerequisite, fodder yield is improved, stall feeding is forced	Environmental regeneration/conservation and reduction in pressure on existing forests
C. On forest panchayat land managed by the village level institutions						
Afforestation/ reforestation	Reinvestment of forest resource based income for improving forest resource capital is not essential in the	Adequate technological knowledge	Improvement in the state of community forests and associated environmental benefits	Economic benefits likely form levies fixed on the local population	Foresty panchayat can mobilize but cannot force community efforts	Forest regeneration/ conservation

	existing management framework, low preference of people for tree planting					
Cultivation of temperate bamboos	Reinvestment of forest resource based income for improving forest resource capital is not essential in the existing management framework, low preference of people for tree planting	Adequate technological knowledge	Improvement in the state of community forests	Economic benefits likely form bamboo based cottage industries	Foresty panchayat can mobilize but cannot force community efforts	Forest regeneration/ conservation
Cultivation of medicinal plants	Reinvestment of forest resource based income for improving forest resource capital is not essential in the existing management framework, low preference of people for tree planting	Adequate technological knowledge	Improvement in the state of community forests	Significant monetary benefits likely from sale of produce	Foresty panchayat can mobilize but cannot force community efforts	Forest regeneration/ conservation
D. On government owned State forests						
Any intervention included in B and C above	Alienation of people because neither they own the land nor they manage the resources, expertise for timber management in conventional forestry	Adequate technological knowledge	Forest regeneration/ conservation	Economic benefits likely from the sale of produce	Negligible because of people's alienation towards government property	Forest conservation/ regeneration

forests have received least attention in land development programmes. Choosing the task of rehabilitation of these lands offered dual opportunity of escaping the conflicting interests, attitudes and jurisdictions of preexisting institutions/individuals on one hand and drawing from the past experiences on the other. The wider objective set was to identify, test and promote interventions on degraded village lands rendering environmental, economic and social benefits together by building on locally available resources, knowledge, skill and institutions with appropriate technological inputs and minimum financial investment.

6.2. Rehabilitation Package Design - The Chosen Elements of Technology, Economics and Society

6.2.1. Logical Framework

Rehabilitation package designed was based on following conclusions/assumptions and elements drawn from analysis of development interventions tried in the past the selected villages or in similar areas elsewhere.

(i) Regional environmental concerns for posterity such as conservation of soil, water, forests and biological diversity are not the priority concerns of villagers.

Environmental conservation objectives and activities have so far failed to earn desired credibility among villagers partly because of poor rural economy and partly because of weak linkages between environmental conservation and economic development activities. Considerable investment has been made for resource conservation in the Himalaya. Conservation programmes included treatment of selected micro-watersheds by measures such as setting up water harvesting structures, check dams, afforestation and pasture development. These conservation programmes instituted since 1977-78 were implemented through centrally sponsored schemes wherein 100% assistance, comprising 50% grant and 50% loan, is provided to the State Government by the Central Government. Villagers could not identify themselves with these programmes for two main reasons - target areas (micro-watersheds) were identified purely on ecological state of degradation and village institutions were marginalised in programme design and implementation tasks. All this established a negative or callous attitude for conservation in the common villager. Land rehabilitation programmes for village common lands lacking development linked conservation focus are therefore not likely to succeed.

(ii) Long term intangible environmental goals can be achieved provided measures required for achieving the goals appreciate the local short term/immediate economic and essential needs.

The apathy towards importance of intangible environmental benefits among villagers originated because of weak integration of Government sponsored schemes addressing tangible economic benefits and intangible environmental benefits. Government support schemes providing direct tangible benefits such as supply of high yield variety seeds and chemical fertilizers at subsidized price, creation of employment opportunities, credit and loaning arrangements for self-employment alongwith efforts for improvement infrastructural facilities were instituted much before the environmental conservation and regeneration programmes focusing on intangible long term benefits. While economic development activities were being addressed by a number of agencies, environmental conservation/regeneration became the responsibility of one agency *viz.*, Forest Department. Forest Department carried the responsibility of reorienting its own functions as well as those of other agencies and individuals. Also, the advocacy for integrating environmental and economic benefits received more attention than finding out ways and means of achieving the new goals.

(iii) Villager's development perceptions tuned to inflow of financial aid, low interest loaning/credit facilities and provision of inputs at subsidized price or free of cost need to be reoriented towards options of building on local knowledge, resources and environmental opportunities.

Capacity of Government to mobilize financial resources are limited. Mechanisms of promoting development through financial aid and loan could be stimulatory but not sustainable in the long run. At some stage, return considerations are bound to check or stop aid commitments. Further, continued dependence upon external aid accompanies erosion of local capacity. Inflow would be appropriate where opportunities for realization of monetary profits from local resources are lacking. In many high altitude villages, such as the present ones, sustainable opportunities of economic development are sub-optimally utilized. Villagers can substantially improve their income from the present level of farm and forest produce by getting rid off from contractor mediated marketing system. Such positive changes could be facilitated by creating awareness towards realities of economics. Perspective of rehabilitation of degraded public or common lands should be expanded from merely tree planting to social and economic development issues concerning other production systems such as farm lands. Improvement in privately owned farm lands can satisfy immediate local subsistence and economic needs and could promote people's participation in rehabilitation of degraded common lands for a mix of environmental and economic development objectives.

(iv) Degraded community lands are the sites appropriate for demonstrating the management of biodiversity satisfying the villager's priority of income generation and environmental regeneration/ conservation objectives in several ways.

Biodiversity concerns stressed emphasis on avoiding or restricting human interference in natural forest ecosystems, particularly the areas characterised by low level of human interference in the past. Rehabilitation efforts on degraded lands laid emphasis on reestablishing tree cover and not on restoring the biodiversity values *per se*. Decline in farm biodiversity and biodiversity of common lands has never been a serious concern earlier. Efforts for increasing farm diversity were made not by diversifying the cultivated crops but by encouraging farmers to introduce trees on farm lands. Programme incentives included distribution of some seedlings free of cost to the farmers by the Forest Department. Subsequently, growing conflicts on choice of species (hardy species escaping the risks of browsing and grazing preferred by the Government agencies for demonstrating their success in terms of survival and species of local uses preferred by the villagers) between Government agencies and villages led investments in establishment of decentralized nurseries maintained by the people. The anticipated benefits of these investments in terms of improvement in tree cover on farms or on common lands could not be achieved. Programme planning assumed that distribution of seedlings free of cost would ensure planting and maintenance of plantation free of cost. Mobilizing self-initiatives for tree planting by other attractive options to farmers were not considered. The programmes also expected that cost of seedling production and subsequently planting by the users will be gradually reduced and eventually a market would be developed for seedlings on a regular basis.

Uses of biodiversity as a resource need to be established considering both economic and environmental development objectives. In order to make rehabilitation programmes as people's programmes, choice of planting species out of an array of potential species should be guided by local needs and priorities to maximum possible extent. Species found appropriate for introduction for enhancing the biodiversity values integrating short term and long term benefits in the target area are given in Table 10. Artificial regeneration of temperate bamboos, medicinal plants, and high value timber trees were chosen as key elements of rehabilitation package after examining diverse aspects of indigenous knowledge, natural potential, demand and availability, and economic values. Specification of integration in terms of relative proportion of the constituent species and their planting configuration, would depend upon the microsite conditions, availability of planting material and preferences of the villager. By appreciating villager's needs and local knowledge in making choice of species, commitment of village in protecting the sites from open grazing could be sought.

Table 10. Species preferred by locals for rehabilitation of degraded land

Common name	Scientific name
Pangar	*Aesculus indica*
Angoo	*Fraxinus micrantha*
Raga	*Abies pindrow*
Deodar	*Cedrus deodara*
Bikua/Jhatela/Bekuva	*Princepia utilis*
Chirad	*Litseolea consimilis*
Bhanj	*Quercus incana*
Kharsu	*Q. leucotrichophora*
Kharik	*Celtis australis*
Bhimal	*Grewia optiva*
Raga/Rai	*Picea smithiena*
Sandan	*Ougeinia delbergioides*
Ruina	*Cotoneaster bacillaris*
Akhor/Akrot	*Juglans regia*
Ayar	*Pieris ovalifolia*
Bhojpattar	*Betula utilis*
Burans	*Rhododendron arboreum*
Khamia	*Acer caesium*
Surai	*Cupressus torulosa*

(v) Compromises on technological choices for regeneration should be made based on an integrated view of conventional scientific efficiency criteria, indigenous knowledge and practical problems posed by inaccessibility and poor infrastructure in the remote marginal areas.

Tree planting could be undertaken by two means, by raising seedlings and their transplants or by transplanting seedlings collected from the wild. The latter method would be advantageous from the point of skipping the period of nursery raising but would be sustainable when natural regeneration is profuse. Choice of this method would also be guided by the technological feasibility of nursery raising. A species like bamboos could be propagated by both vegetative means and seeds. However, long cycles of flowering and high risks of predation of seeds make seed based propagation impractical. Mass propagation by advanced biotechnological techniques (Mehta *et al.*, 1982; Nadgir *et al.*, 1984; Rao *et al.*, *1992*) is feasible. However, biotechnological advancements in the country have not been tested for.

their efficacy for temperate bamboos growing in high altitudes. Bamboo propagation through offsets would have an added advantage of soil stress tolerance, fast growth and thereby early crop of harvestable culms in comparison with seed or seedling propagation (Rao & Ramakrishnan 1987; Rao & Ramakrishnan, 1989). A majority of medicinal plants native to high altitudes also reproduce by vegetative and sexual means. Since these species usually are characterized by random rather than contagious distribution, obtaining propagules from the wild is more tedious task than that of bamboos growing abundantly and mostly exhibiting contagious distribution. Natural pockets of occurrence of medicinal plants are more inaccessible than those of trees and bamboos. Local knowledge on distribution, flowering, fruiting and germination requirements is quite rich. Choice of propagation techniques would thus be determined by multiple considerations.

(vi) Partial funding of any common land rehabilitation programme is likely to be an unproductive investment. People's participation in terms of voluntary contribution could be expected after a period of at least 5 years in these areas.

Villagers have neither financial capacity nor intentions for improving their economy by treating common lands. Anticipating people's participation in terms of voluntary labor would not be a realistic proposition. Participation of villagers has been found to be the key element rendering success to rehabilitation and resource management endeavors more than conventional afforestation/reforestation activities and regulation of villager's rights of resource use in common and public lands (Khoshoo, 1987; Anonymous, 1988; Grewal *et al.*, 1990; Ramakrishnan *et al.*, 1992; Malhotra & Poffenberger 1989). Resource sharing issues and people-public/Government conflicts have been discussed by Ramachandran *et al.,* (1994). However, level of financial investment has not been made transparent in these success stories. Financial indicators in Government sponsored rehabilitation programmes are available but comparable figures in participatory approaches are not available. It is contended that adequate funding would be a prerequisite for making participatory approaches successful. Investment and returns are difficult to predict because of diversity of preexisting environmental and socio-economic conditions and risks/ uncertainties involved in the outcome of tried interventions. Key issue in financial considerations should be multiple checks and balances on expenditure and transparent decisions on reinvestment or sharing of benefits. The best check would be to involve local institutions not as expenditure making agencies but as expenditure examining agencies. The returns from rehabilitation would accrue after at least 5 years and are likely to be of much lower order than the aid flowing through other development programmes. Instead of emphasizing on the reinvestment, emphasis should be laid on sharing of benefits by the community in ways which favor social equity.

(vii) Consensus decision making and informal arrangements with village level

institutions and individuals would be more effective than selected or elected elite dependent actions and arrangements.

Hill villages are not so vast that assembly of entire village community becomes unmanageable. Conflicts and non-cooperation usually originate from distortion of opinions and understandings if selected or elected individuals who in turn own the responsibility of ensuring cooperation of the village community are taken in confidence by any development agency. The elites or powerful individuals do matter when any interference, in village territory is attempted. By ruling out the possibility of channeling funds through single institution, it would be possible to get away from conflicts between Forest Panchayat and Village Councils. The best strategy would be not to sideline or disregard these institutions but to convince their representatives about advantages of consensus decision making.

(viii) The objective circumstances of the villages demand collective and cooperative village level initiatives for realizing the monetary profits of the produce.

Monarable roads are the top most development priority in inaccessible high altitude villages. Natural constraints of rolling landscape and limitations of public funds together with political factors render several uncertainties about as to when these villages would be connected by motorable road. Villagers foresee all advantages with motorable roads and not the huge financial and environmental costs involved in expansion of road network. For realizing the monetary benefits from the farm and forest produce or from degraded land rehabilitation activities, the circumstances demand collective and cooperative marketing initiatives for resisting the contractor mediated exploitation and for competing in the growing liberal market economy. Mearly getting connected by motarable road would not help the villagers in these difficult high altitude areas.

6.2.2. Village Specificities

Within the scope of a logical framework delimited by above propositions, specific activities to be undertaken in each of three selected villages were planned. Site characteristics, preferences of population, initiatives and enthusiasm of local population towards rehabilitation activities, natural resource potential, and practical considerations of supplementing/ complementing the local knowledge formed the basis of screening the treatments and options. Protection of site (a consolidated acreage of 12-15 ha) by way of mechanical fencing using locally available stones and also persuading the community to consider open grazing in the area as a social offence was the starting step of site work. This was followed by initiating efforts for promoting artificial regeneration of appropriate species. All the three village communities felt it appropriate to introduce temperate bamboos. However, there was a

callous or even opposing attitude towards tree planting but not to the same extent in all villages. This was perhaps a reflection of discouraging results of afforestation efforts made in nearby areas. Close interaction and persuasion of scientists involved in the project and cooperation of a Nongovernmental Organization (NGO), people in two villages *viz.*, Mikhila and Khaljhuni could be convinced for introducing a mixture of bamboos and trees of their choice. Trees were proposed for introduction in microsite conditions not favorable for temperate bamboos (microsites characterized by thin and gravelly soil). Chowda village community was rigid in its negative attitude towards tree planting. After these activities took off and scientists-villagers association started getting stronger and stronger, ideas of other productive options such as cultivation of medicinal plants and cooperative initiatives for realizing the monetary values of the local produce by resisting/evading the existing exploitive marketing mechanisms were floated. It took a year for mobilizing people's initiatives towards cultivation of medicinal plants on common lands; that too only in one village, *viz.*, Khaljhuni, out of the three. Some options had positive implications for the privately owned farms also. A favorable change in marketing arrangements would certainly not be of direct relevance to rehabilitation activity at present, but would certainly improve the contribution of traditional farming in rural economy. Such a positive change is likely to promote people's participation in rehabilitation of degraded lands. Rehabilitation packages for degraded common/forest lands under the present mountain circumstances ought to be flexible and should be integrated with improvements in private farm based rural economy.

6.2.3. Planting Material and Techniques

A nursery was established in village Khaljhuni for introduction of trees. Four species *viz., Quercus leucotrichophora* (a fodder and fuelwood tree), *Juglans regia* (dry fruit tree also used for extracting natural dye and of medicinal values), *Aesculus indica* (a fast growing tree whose leaves have soil fertility as well as fodder values) and *Fraxinus micrantha* (timber used for agricultural implements and wood wares) were selected (Table 11). These species were represented in the natural flora and so were considered ecologically adapted species. Because of their local utility values and distribution in far off places, their plantation in degraded common lands near the village was acceptable to the people. Transplanting was done in October, the end of summer monsoon.

Temperate bamboos were propagated through offset planting technique. Surrounding areas were surveyed for identifying the locations where offset collection from the natural habitat was not likely to affect adversely the natural regeneration (locations with profuse regeneration and microclimatic conditions favoring bamboo growth). Offsets were collected in the month of June/July, screened for healthy viable buds and planted to the site within 24 hours. It was this activity where availability of villagers was ensured to maximum possible extent since immediate planting was

likely to be more useful from the point of establishment.

Table 11. Output from nursery developed at Khaljhuni

Species	Number of seedlings/saplings
Quercus leucotrichophora	7,000
Juglans regia	3,000
Aesculus indica	12,000
Fraxinus micrantha	3,000

Soil conditions are usually not considered systematically for forest related activities. Forest species are usually presumed to be capable of growing even in stressful environments. Survey of reforestation/afforestation efforts indicated neglect towards soil management as a major factor limiting the success of plantation efforts (Saxena *et al.,* 1990). Diversion of resources towards soil management is bound to reduce the acreage treated, but is likely to improve the probability of success in plantation efforts and thereby productive investment. Transplanting was done in pits of 30 cm x 30 cm x 30 cm size. Gravels from the dug out soil were removed and soil was mixed with 500 g of organic manure available locally. While filling the pits, care was taken to avoid water stagnation in the events of rains.

6.3. Operational Framework of Seeking People's Participation

As discussed above, people's participation in developmental activities potentially serves three objectives - reduction in investment by development agencies, more secured success of efforts and returns, and enhancement in development oriented thinking by the villagers. Establishing successful partnerships with villagers demands a number of careful considerations and actions, the most important among which is a paramount importance to the people in making choices and decisions. One must acquire a thorough understanding of not only the existing problems but also the preexisting attitudes and likely responses. NGO's could facilitate the process of digging out the positive and negative aspects of past development efforts by the researchers (Fig. 11). It must not be forgotten that NGO's are also individuals as are development officials in Government system or scientists as more independent community. Individuals may not be necessarily committed for the cause of others. In order to get close to the people, a prerequisite for establishing strong partnership, living with the people seems to be the only practical mechanism. This also certifies the commitment of those who come forward with sustainable development advocacy. The partnership should aim for complementary/ supplementary roles. Checks and

Setting the Goal → Socio-economic development of selected villages by capitalizing upon the available resources, local knowledge and skill with appropriate technological and financial inputs

↓

Discussion with Government officials

↓

Reconnaissance survey of the Block and selection of villages → High altitude remote villages far away from conventional development agencies - the most marginalised among the marginalised villages

↓

Identification of core activity:
Land redevelopment on degraded village/community lands

↓

Informal discussions with village elites, elected individuals, socially and economically powerful individuals, on project elements, benefits and costs, and choices for selection of a piece of village land (size 5 to 15 ha)

→ Establishing partnership with villagers

↓

Informal discussion with Forest Panchayat, Gram Sabha Officials on choices for land redevelopment activities appropriate from technological, institutional and financial considerations

→ Establishing partnership with the villagers

↓

Persuading village level institutions (Forest Panchayat and Gram Sabha) for decision making on identification of specific activities and their implementation mechanisms in the entire village community and for endorsements of such decisions by the existing village level institutions viz., Gram Sabha and Forest Panchayat

→ Decision making by consensus for meeting social, economic and environmental development objectives together

↓

Decisions of land to be treated and interventions for land redevelopment

Fig. 11. Course of action adopted for seeking villagers' participation

balances by one partner on the other should replace the conventional status consciousness in donor-recipient relationships in conventional administered development system. Open dialogues in a forum of entire village community is the best way of consensus decision making. However, one should not neglect the 'elites' represented in established institutions including village council and Forest Council. Disbursement of money in the presence of these 'elites' but not through them was conceived as an action which would earn credibility of preexisting institutions/elites and the common man simultaneously. Project managers must demonstrate their capacities of persuading these elites for promoting activities serving the objectives of the project.

6.4. Impacts of Rehabilitation Model Tested

A period of 3-4 years is too short a period for assessing the environmental costs/benefits impacts in quantitative terms. Moreover, majority of environmental benefits are intangible. Costs of measuring environmental parameters like soil erosion, hydrological cycling are also very high, more so in remote areas. These measurements serving scientific interests and not benefiting the villagers directly, may become counterproductive to participatory land rehabilitation objectives. This possibility becomes stronger where projects are small as villagers develop an understanding that scientific interest is the primary motive and rehabilitation the secondary one. All the three sites represented severe levels of degradation of natural vegetation - < 5% crown cover, soil depth ranging from 5 cm to 40 cm in the site, steep slopes (35 degree to 50 degree), abundance of non-browsable and low fodder value species. Improvement in vegetation cover under such a condition is known to accompany many other environmental benefits. Economic and social impacts in participatory endeavors are more easy to analyze as they are easily understood by the villagers.

6.4.1. Environmental Impacts

(i) Accelerated Regeneration of Vegetation Cover

Vegetation cover of the site was improved partly by protection of the area from open grazing and partly by introduction of transplants. In all the sites, regeneration of trees by natural means (from *in situ* soil seed bank and/or seed rain from the surrounding areas) was nominal (12-35 seedlings per ha) and over 95 % of the naturally regenerated trees suffered mortality. Natural regeneration of bamboos was altogether lacking. Thus, simply by protecting the area from human interference, the process of natural regeneration would be extremely slow. Artificial regeneration therefore is essential for accelerating the regeneration process in degraded lands.

Data on establishment and survival of transplants (Table 12) indicate varied

degree of success. For tree species, production of new leaves within a year was considered as a measure of survival and continuation of the same during second year as establishment. In case of bamboos, production of new leaves during first year following transplant was considered as a measure of establishment and production of new culms along with production of new leaves on the transplanted culm as a measure of establishment. Survival of bamboos was higher than that of tree species in Khaljhuni and Mikhila where both the constituents were introduced. In village Chowda where only bamboos could be introduced, survival percentage was lowest. In two sites *viz.*, village Mikhila and Chowda, there was high mortality following a year of transplant. This was largely because of lack of seriousness of villagers in replacing the casualties, an activity which was not financially supported in the project. Comparing villages Mikhila and Chowda where participatory efforts for reforestation proved to be utter failure, the failure is more conspicuous in latter village where only one species (bamboos) was introduced than the former where a mixture was introduced. This suggests that risks of failure with mixed plantations are less. Reluctance of villagers in maintenance and care could also be because of alternative opportunities of tourism based income generation in village Chowda. The reason for limited success in village Mikhila seems to be lack of scarcity of forest resource in the village. The success in village Khaljhuni was because of limited availability of bamboos from the village forests. The success of plantation efforts, even though the choice of species is made based upon local knowledge and preferences, would depend upon several other factors like villager's attitudes towards alternative economic activities and magnitude of scarcity of the species planted. The results also suggest that plantation activities should be undertaken in phases treating smaller areas initially followed by larger acreage treatments depending upon the success achieved in the initial phases.

Table 12. Outcome of the plantation efforts made in the study villages

Species	Chowda		Khaljhuni		Mikhila	
	A	B	A	B	A	B
Thamnocalamus falconeri	-	-	80	72	80	11
Chimnobambusa falcata	52	2	-	-	-	-
Juglans regia	-	-	25	23	3	3
Quercus leucotrichophora	-	-	13	9	0	0
Aesculus indica	-	-	63	60	12	11

A: % establishment; B: % survival; -: not planted

(ii) Soil Conservation and Fertility

In all the three sites, irrespective of success or failure of transplants, soil erosion must have been reduced by elimination of overgrazing, though there are not data to support this conclusion. Because of addition of organic manure during plantation, soil fertility levels must have also improved. However, these impacts do not provide any direct immediate benefits to the villagers.

(iii) Conservation of Biological Diversity

To what extent biodiversity gets conserved through land rehabilitation would depend upon the degree of success achieved in reconciling regional environmental and local economic interests. Biodiversity gets conserved by enrichment of the treated degraded sites on one hand and reduction of pressure on existing wild areas on the other. This would depend upon the initiatives and attitudes of people. Conservation through enrichment was least effective in most accessible village Chowda. Comparing the two most remote villages Mikhila and Khaljhuni, enrichment in terms of species introduced in degraded sites was high in the latter village because people could be persuaded for cultivation of medicinal plants also. Only in village Khaljhuni where plantation efforts were most successful, medicinal plants (*Picrorhiza kurrooa; Orchis latifolia; Angelica glauca; Thalictrum foliolosum; Mentha arvensis; Rheum emodi; Aconitum heterophyllum; Swertia chirata; Nartostachys jatamansi*) could be introduced. Perhaps, the villagers could realize the economic values of biodiversity in situations when they are deprived of more secured alternative opportunities are also faced to a scarcity of needed plant resources.

6.4.2. Socio-economic Impacts

(i) Deployment of Human Resource

A direct economic impact relates to wage earning by the local population. These were male members from the village community who came forward for wage earning in the project activities including fencing, nursery, collection of planting material from the wild, and site protection. The reasons for participation of men and not women were (i) wage earning by undertaking physical tasks by women is not acceptable in the local socio-cultural system (ii) women were overburdened by the agricultural and other domestic work such as collection of fodder and fuelwood. Land rehabilitation activities thus provide productive deployment of unoccupied male manpower. Considering all the sites together, about 1000 man days employment potential was supported by one hectare of degraded land. Investments in different components are given in Table 13. Least voluntary participation in fencing and protection led to bulk investment in this activity.

Table 13. Economic indicators of rehabilitation cost

Component	Chowda			Khaljhuni			Mikhila		
	Ist	IInd	IIIrd	Ist	IInd	IIIrd	Ist	IInd	IIIrd
Involvement of NGO	11221	11221	1558	11221	11221	1558	11221	11221	1558
Nursery cost (Rs/surviving seedling)	-	-	-	0.5	0.5	nil	-	-	-
Plantation cost (Rs/ha)	6450	nil	nil	5000	nil	nil	5000	nil	nil
Plantation cost (Rs/plant)	6.5	nil	nil	4.5	nil	nil	5.3	nil	nil
Land preparation cost (Rs/ha)	1500	nil	nil	1500	nil	nil	1500	nil	nil
Collection of planting material from the wild - medicinal plants (Rs/plant)	-	-	-	150	150	150	-	-	-
Collection of planting material from the wild - bamboos (Rs/plant)	0.15	nil	nil	0.15	nil	nil	0.15	nil	nil
Other costs (Rs)	3600	3600	3600	3600	3600	5400	3600	3600	3600

(ii) Fodder Availability

Women got involved in grass cutting component of fodder management which was not a wage earning task in the work plan. Protection of site favored palatable grass growth and this provided considerable relief to women from preexisting practice of fodder collection from the far off forests. Crisis of green fodder was most felt in village Chowda and Khaljhuni and in both the villages objective of improving upon fodder availability in treated site was achieved. People of these two villages used to purchase grass fodder from surrounding villages at the rate of Rs 0.40/ kg. Not only a substantial amount on fodder procurement was saved, but rehabilitation process facilitated collective cutting and equal sharing by all the beneficiaries. Village community was convinced to cut grass once in the month of September/ October. Since fodder collection was the responsibility of women in the local systems, women got involved in the rehabilitation process. Village community decided that one member of each household would be involved in cutting process and the produce would be shared on equal terms. During the first year, fodder yield was 0.9 t/ha and it increased to 1.2 t/ha during the second year after which it was stabilized.

(iii) Supplementary Food

Utility values of degraded lands could be improved by incorporating wild edible fruit trees and shrubs. In the present attempt, only one species *viz.*, *Juglans regia* could be introduced in two village sites. However, the gestation period between transplanting and fruiting is too long (fruiting is likely to take off after 15-20 years age). For a considerably long period, there would be intangible environmental benefits like soil and water conservation. As indicated in preceding chapters, trees have multiple use values. Under the present circumstances, wild edibles could only supplement local diets as there are weak market demands for the produce.

(iv) Income Generation from temperate bamboos and medicinal plants

Temperate bamboos were the key species in the rehabilitation package. It had advantages from the point of local skill of income generation through bamboo handicrafts, increasing/likely scarcity of raw material and short period of maturity of the crop. Tree species introduction could be tied up with this central activity in two villages. In one village, initiatives for medicinal plant cultivation followed as a secondary activity as result of success achieved in primary focal activity *viz.*, bamboo regeneration. Estimates on harvestable produce and monetary profits from bamboo cottage industry from the treated site in village Khaljhuni where rehabilitation efforts

Table 14. Cost-benefit analaysis of plantation in Khaljhuni

Item	Year										Total
	1	2	3	4	5	6	7	8	9	10	
Costs											
Plantation	75000	nil	nil	nil	nil	nil	nil	nil	nil	nil	75000
Maintenance[1]	42321	15821	7958	5400	5400	5400	5400	5400	5400	5400	103900
Total	117321	15821	7958	5400	5400	5400	5400	5400	5400	5400	178900
Benefits											
Fodder	18000	21000	21000	21000	21000	21000	18000	15000	13500	13500	183000
Bamboos*	nil	nil	nil	200	500	800	1000	1000	1000	1000	5500
Medicinal plants[2]	nil	nil	3000	4000	4000	5000	5000	5000	5000	5000	36000
Total	18000	21000	24000	25200	25500	25800	24000	21000	19500	19500	224500

1 Includes expenditure for medicinal plants plot (0.03 ha) also.
2 Returns are from only 0.03 ha area where medicinal plants were planted.
* values are only the fee chargeable for collection of bamboos as the resource itself is seen as free commodity.
Projected values are used for sixth year onwards.

were most successful, are given in Table 14. Utilizable raw material is likely to be available from 4th year following plantation increasing upto 8th year, and reaching stability at this stage. Monetary profits are increased by less amount of labor on obtaining the material from a site close to the village.

Out of 12 medicinal plant species tried, Kutki (*Picrorhiza kurrooa*), Atis (*Aconitum heterophyllum*), Dolu (*Rheum emodi*) and Gandharayan (*Angelica glauca*) proved to be most promising. Harvestable yields from vegetatively propagated plants started from 3rd year. Many of the medicinal plants are shade tolerant and so a mixture of these species with trees/bamboos becomes advantageous both from environmental and economic considerations.

(v) Within Village Cooperation and Equity

Social inequity related to gender differentiation or socially privileged and underprivileged groups was reduced. In general, the village institutions are characterized by dominance of men. Women thus have a little stake in decision making on developmental issues. Bringing in fodder management, a responsibilities of women in the local system, in the rehabilitation package promoted women participation. Indeed, women never came forward by themselves but could influence the men in taking decisions on usufruct aspects of fodder sharing. Low economic group people who also hail from socially underprivileged sections earned wages. Maintenance, monitoring and collection of propagules from the wild, work elements for which compensation by wages was kept nominal, were performed by all social groups. Thus equity was promoted by mechanisms which appreciated the socio-cultural values of the society.

(vi) Enhancement in Local Awareness and Knowledge

Open dialogue and informal discussions with the villagers led to improvement in local knowledge on the options of realizing the development potentials of local resources and their uses.

6.5. Future Considerations

* Enormous variation at short distances in environmental, economic and social determinants within a segment homogeneous in respect of one parameter like altitudinal spread makes it difficult to design a uniform land rehabilitation package for vast areas.
* Success of efforts on environmental regeneration of degraded lands in the fragile Himalayan landscape made so far has not been attractive because of ignorance of local socio-economic needs and people's participation in decision making.

* Conventional linear model of research, technology development and transfer/ extension would not be suitable in the region because it fails to understand the variability in multiplicity and severity of problems and their linkages. Thus scarcity of forest resources is a generalized problem for the region and this generalization may not hold true for individual villages.
* Local knowledge on biological production systems is extremely rich and provides scope for improvements through conventional science and technology. Building on local knowledge minimizes the risks of failure of interventions and investments.
* Deciding quantum of investments on land rehabilitation tasks based on conventional economic cost/benefit analysis has little rationality because many benefits are intangible and returns start after 3-4 years. Conventional 5 year project planning is not justified for land rehabilitation projects.
* There are multiple facets of integration - integration of off-farm and on-farm economy, integration of crops, animal husbandry, forests and human systems, integration of research, technology development and technology transfer, integration of people, government and nongovernmental organizations, integration of tangible and intangible benefits, integration of short term and long term development objectives. There are a spectrum of choices for achieving a given objective. Informal dialogue and discussion leading to consensus decision making seems to be the most appropriate mechanism of achieving best workable integration.
* Progress in rehabilitation of degraded lands is limited not as much by technological constraints as by implementation constraints. People's participation in governmental efforts can only reduce the problem.
* For achieving people's participation, a village should be considered as an independent unit for land rehabilitation programme planning and implementation.
* Rehabilitation programmes should address issues concerning not only improvement in production of scarce resources but also on realization and appropriation of monetary benefits from the produce. This would reduce the cost of rehabilitation in the long run and would mobilize local initiatives.
* Massive afforestation/reforestation programmes treating large acreage and involving huge investments are impressive but scientific and institutional support for absorbing the huge investment is not strong enough to ensure returns commensurate to huge investments. Financial investments are likely to be more productive if success stories spread from village to village experiences. Level of people's participation in rehabilitation programmes in past should determine the quantum of investments in the future. Success stories on integrated development in the region itself are rare.

7. CONCLUSIONS

With a variety of ecological situations, socio-economic conditions and socio-cultural variations in the Himalayan region, developmental strategies neces-

sarily have to be location-specific. If they are based upon traditional technologies of the region, they would find acceptance by the people concerned. Only then would the peoples' participation be ensured, as it would be based on a value system that the people can appreciate and identify with. The world's population is increasing at the alarming rate of 80 million people per year, and demographic pressures are more pronounced in the developing world. Consequently, deforestation in the tropics is essentially a human problem, rural and a narrow-based forestry initiative alone can't tackle it (Ramakrishnan, 1992c). A more broad-based interdisciplinary approach will facilitate the sharing of knowledge arising out of the three major components of the management strategy (Fig 12). Linking up forestry with sustainable development of rural communities by making adequate provision for food, fodder, fuelwood and timber to meet daily needs is critical. In this effort and in providing cash income for a better quality of life, multipurpose species can play a useful role. Such species could also markedly reduce pressure on natural forests. Sustainable development with peoples' participation demand closer interaction between ecologists and social scientists who have traditionally worked in isolation, using different paradigms for development. It also calls for interaction between planners, non-governmental organizations and the local communities. That is what sustainability is all about. No

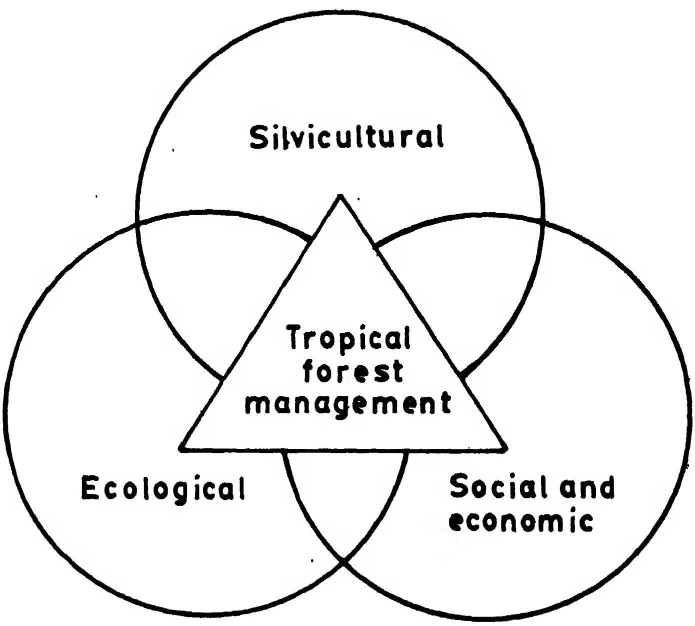

Fig. 12. Interdisciplinary interactions called for in tropical forest management and conservation (after Ramakrishnan, 1992 c)

where is this holistic approach to sustainable development more crucial than in the Himalayan region.

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